ME-7858

INSTRUCTION MANUAL

RF SUBSYSTEM

Y388

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Scientific Atlanta

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SECTION 1. GENERAL DESCRIPTION

1.1 INTRODUCTION

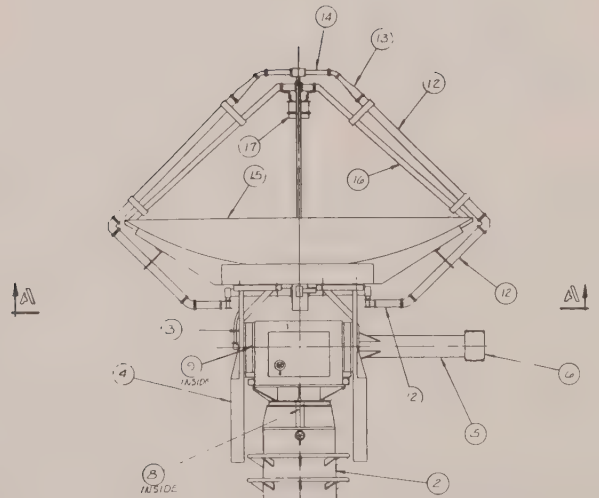
1.1.1 SCOPE. This manual describes the purpose, characteristics, functions, installation, operation and maintenance of the Antenna Group of the 157519/161918 S-Band Monopulse Antenna System supplied to National Aeronautics and Space Administration, Goddard Space Flight Center under Contract NAS5-24239 by Scientific-Atlanta, Inc.

Figure 1-1 is a line illustration of the outdoor segment of the S-Band Monopulse Antenna System. This manual covers items 7-20 of this Figure, including: the 14-foot-diameter paraboloidal reflector with vertex test dipole and prime-focus feed assembly; waveguide diplexers and waveguide polarization - select switch; coaxial filters, couplers, power dividers, and preamplifiers; and associated waveguide runs and coaxial lines with single-channel coaxial rotary joints. A separate unit manual is provided for the polarization control unit associated with the polarization select switch. Overall system installation and interface details are presented in the S-Band Monopulse Antenna System technical manual; various other manuals, listed in the system manual, provide operation and maintenance information for the remaining separate units of the overall system.

1.1.2 PURPOSE OF EQUIPMENT. The Antenna Group described in this manual provides for:

(1) transmission of S-Band signals in selectable Right Circular Polarization (RCP) or Left Circular Polarization (LCP) modes, over the 2025-2120 MHz band, at power levels from an appropriate GFE transmitter of up to 500 watts CW and 600 watts peak;

(2) reception and monopulse processing of S-Band signals via a 5-element feed system in both RCP and LCP modes, over the 2200-2300 MHz band, and routing of these signals to a pedestal-mounted GFE downconverter;



LEGEND:

1. Base Extension
2. Pedestal Assembly
3. Sidearm
4. Counterweight
5. Scope Mount
6. Scope Cover
7. 7/8" EIA Connector
8. Azimuth Rotary Joint
9. Elevation Rotary Joint
10. Waveguide Switch
11. Diplexer
12. Waveguide
13. Waveguide Twist
14. Waveguide, Flexible
15. Reflector
16. Spar Assembly
17. Feed Assembly
18. Vertex Dipole Assembly
19. Preamp Enclosure
20. Two-way Power Divider

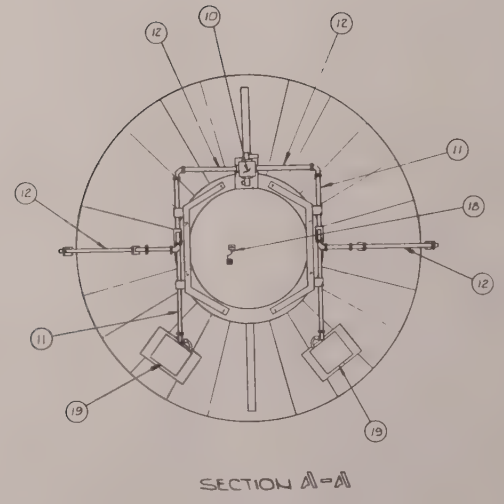


Figure 1-1. Outdoor Segment of S-Band Monopulse Antenna System

(3) self-test circuitry via 2-way and 4-way power dividers into the two receive sum channels and four tracking difference channels of the feed monopulse subsystem, with test inputs provided from appropriate GFE sources; and,

(4) transmitter output monitoring via a vertex dipole and GFE cabling to an appropriate GFE monitor unit.

In combination with the pedestal and control subsystems, and properly connected GFE subsystems, the Antenna Group will be used in automatic tracking, telemetry reception and directed transmission, of S-Band signals associated with operational systems of the Space Shuttle Program.

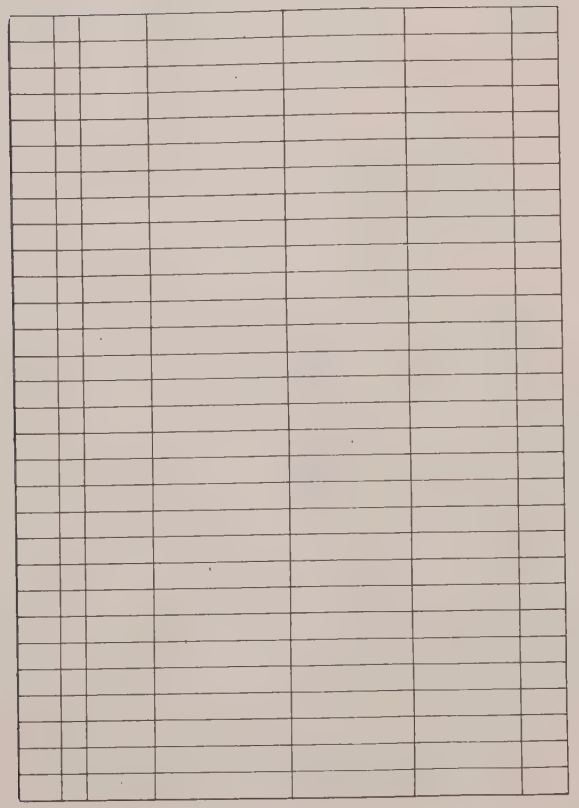
1.2 PHYSICAL DESCRIPTION

The Antenna Group consists of those major components listed in Table 1-1, and associated waveguide and coaxial cable runs.

1.2.1 TRANSMIT COAXIAL INPUT CIRCUIT. The RF interface for the Antenna Group with the GFE transmitter output is the 7/8" EIA connector at the connector panel located near the foot of the base extension for Model 3204 elevation-over-azimuth pedestal; see Figure 1-1.

1.2.1.1 COAXIAL ROTARY JOINTS. The transmit 7/8" coaxial line is routed through rotary joints at the azimuth and elevation axes of the pedestal, as shown in Figures 1-2 and 1-3.

1.2.2 WAVEGUIDE SWITCH. The waveguide switch employed for polarization selection of the transmit path is a Waveline WR430 unit as shown in Figure 1-4. The RF input to this switch is via a 7/8" EIA to WR430 adapter. Each output is WR430 waveguide. The unused output port is connected through the switch to a WR430 to type N adapter and coaxial load at the 4th switch port.



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33						
32	4	72306	SCREW, DRIVE	NO2 X $\frac{3}{16}$, SST		
31	11	73278	WASHER, FLAT	NO 1/4 CAD PL STL	MS27183-10	
30	3	73277	WASHER, LOCK	NO. 1/4 CAD PL STL	MS35338-44	
29						
28	8	73273	WASHER, LOCK	NO 10 CAD PL STL	MS35338-43	
27	7	72491	SCREW, SOC HD CAP	1/4-20 x 5/8 CAD PL STL	MS16997-59	
26	4	72498	SCREW HEX HD CAP	1/4-20 x 1 CAD PL STL		
25	8	72441	SCREW, SOC HD CAP	10-24 x 3/8 CAD PL STL	MS16997-43	

24						
23						
22						
21						
20						
19						
18						
17						
16						
15						
14	1		ROTARY JOINT		33-2049F-0	01882
13						
12	1	112285	TAG, IDENTIFICATION			
11	1	162781	CONN R, AZ HSG			
10	1	161942	MOUNT, R.J.			
9	2	9204	GEAR, SYNCHRO ABL		9204	
8	1	33175	PLATE, CONNECTOR			
7	1	1543	GEAR, LIMIT SWITCH		1543	
6	1	159243	LOWER AZ HSG MOD			
5	1	44887	LIMIT SWITCH ASSY			
4	–	——	SYNCHRO ASSY			
3	1	47290	SYNCHRO ASSY		MODEL 1321M	
2	1	47289	SYNCHRO ASSY		MODEL 1321L	
1	1	98632	AZIMUTH ASSY		98632	
ITEM OR FIND NO	QTY REQD	S-A STOCK NO	NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO	CODE IDENT

PARTS LIST

NOTES:
1. ELECT LIMITS ± 360°
2. SLIP CLUTCH SETTING 9.25 ± 0.25 FT-LBS

Figure 1-2. Component Location Azimuth
3204 Series
(sheet 1 of 2)

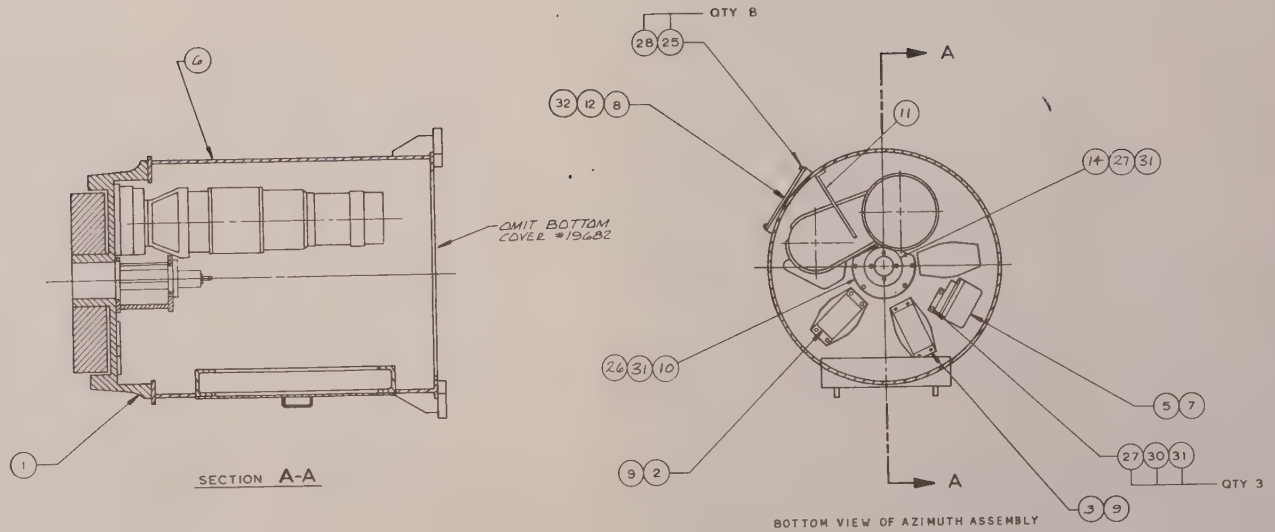

Figure 1-2. Component Location Azimuth
3204 Series
(sheet 2 of 2)

ITEM OR FIND NO	QTY REQD	S-A STOCK NO	NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO	CODE IDENT
56	12	73278	WASHER, FLAT	NO. 1/4 CD PL STL	MS27183-10	
55	4	71608	PIN, DOWEL	1/2 DIA x 1 1/4 CD PL STL		
54	16	72700	SCREW, SOC HD	5/8-11 x 2 3/4 CD PL STL	MS16997-171	
53	8	73277	WASHER, LOCK	NO. 1/4 CD PL STL	MS35338-44	
52	4	72490	SCREW, SOC HD	1/4-20 x 1/2 CD PL STL	MS16997-58	
51	6	80252	WASHER, FLAT	NO. 8 CD PL STL	MS27183-7	
50	6	75776	SCREW, SOC HD	8-32 x 1/2 CD PL STL	MS16997-32	
49	6	83453	SCREW FL HD	8-32 x 1/2 CD PL STL		
48	4	71510	NUT HEX	1/4-20 CD PL STL		
47	4	72498	SCREW HEX HD	1/4-20 x 1 CD PL STL		
46						
45						
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42						
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40						
39						
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37						
36						
35						
34						
33						
32						
31						
30						
29						
28						
27	1		ROTARY JOINT	33-204AF-0	01882	
26	44		WASHER COMPRESSION	DEH150	SCD	
25						

ITEM OR FIND NO	QTY REQD	S-A STOCK NO	NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO	CODE IDENT
24						
23						
22						
21						
20						
19						
18	1	123580	DECAL			
17	1	13 2163	MOD EL WSG			
-16	1	53109	ELEVATION ASSY	MODEL 3204	DWG 98633	
15	1 LOT	72972	GASKET		NO 301 1/8 x 34	83797
14	2	161940	SPACER			
13	2	132169	MANDREL			
12	4	161941	PLUNGER			
11	3	9205	GEAR, A B L		9205	
10	1	47301	SYNCHRO ASSY		MODEL 4321E	
9	1	47290	SYNCHRO ASSY		MODEL 4321M	
8	1	47289	SYNCHRO ASSY		MODEL 4321L	
7	1	1514	GEAR, LIMIT SWITCH		1514	
6	1	44866	LIMIT SWITCH ASSY			
5	4	127630	STRIKER		127630	
4	1	K61943	MOUNT, R.I.			
3		[illegible]				
2		[illegible]				
1	1	161949	COVER TURNTABLE			

PARTS LIST

NOTES:
1. TURNTABLE TRAVEL TO STOP ENGAGEMENT TO BE -5° TO +185°. (ELECT -3° TO +92°)
2. CUT TO LENGTH REQUIRED AT ASSEMBLY FOR SUITABLE SPRING PRELOAD.
3. TO BE STOWED AT ZENITH (+90°)
4. SLIP CLUTCH SET TO 9.25 FT LBS ± 0.25 FT LB

Figure 1-3. Component Location Elevation
3204 Series
(sheet 1 of 2)

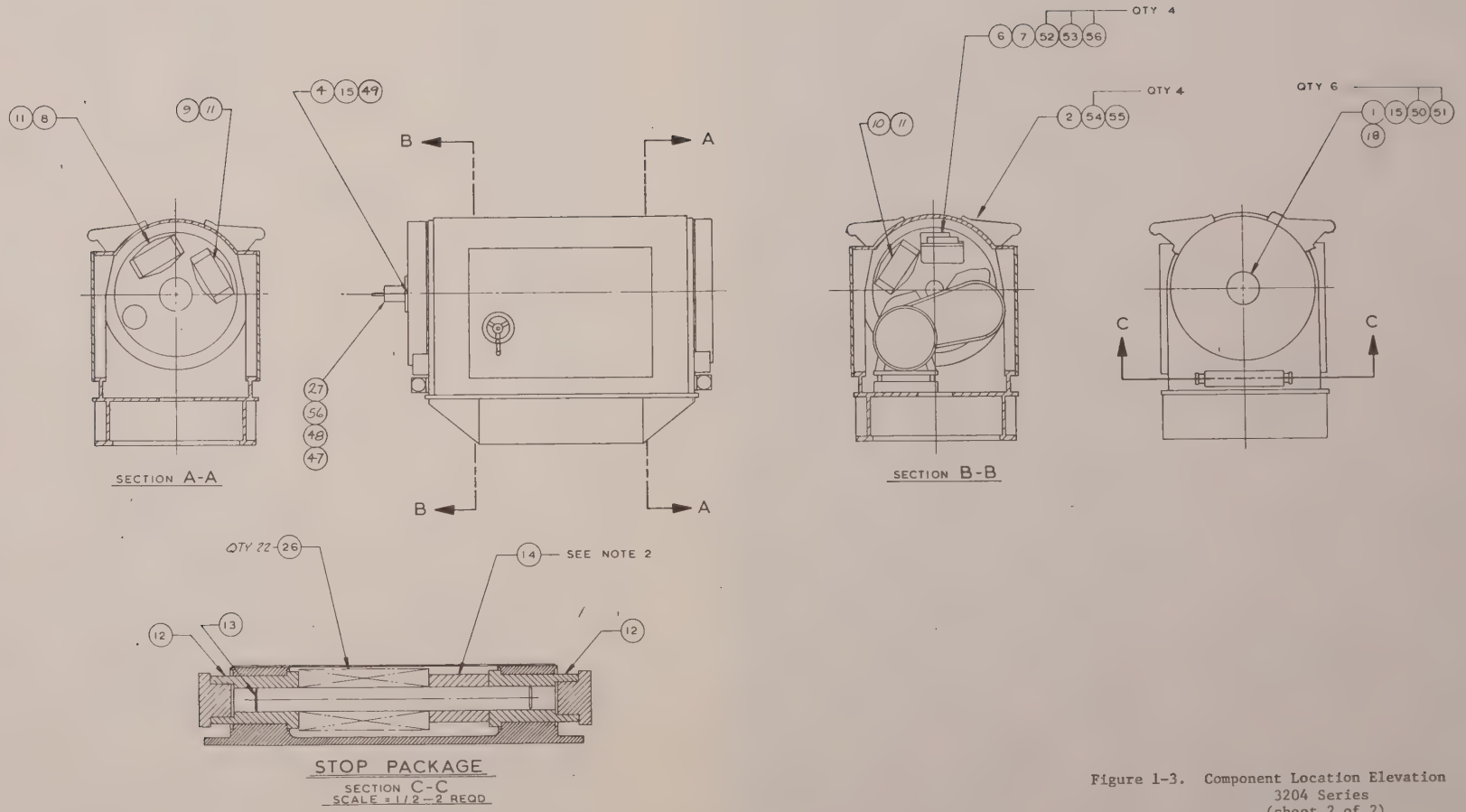


Figure 1-3. Component Location Elevation
3204 Series
(sheet 2 of 2)

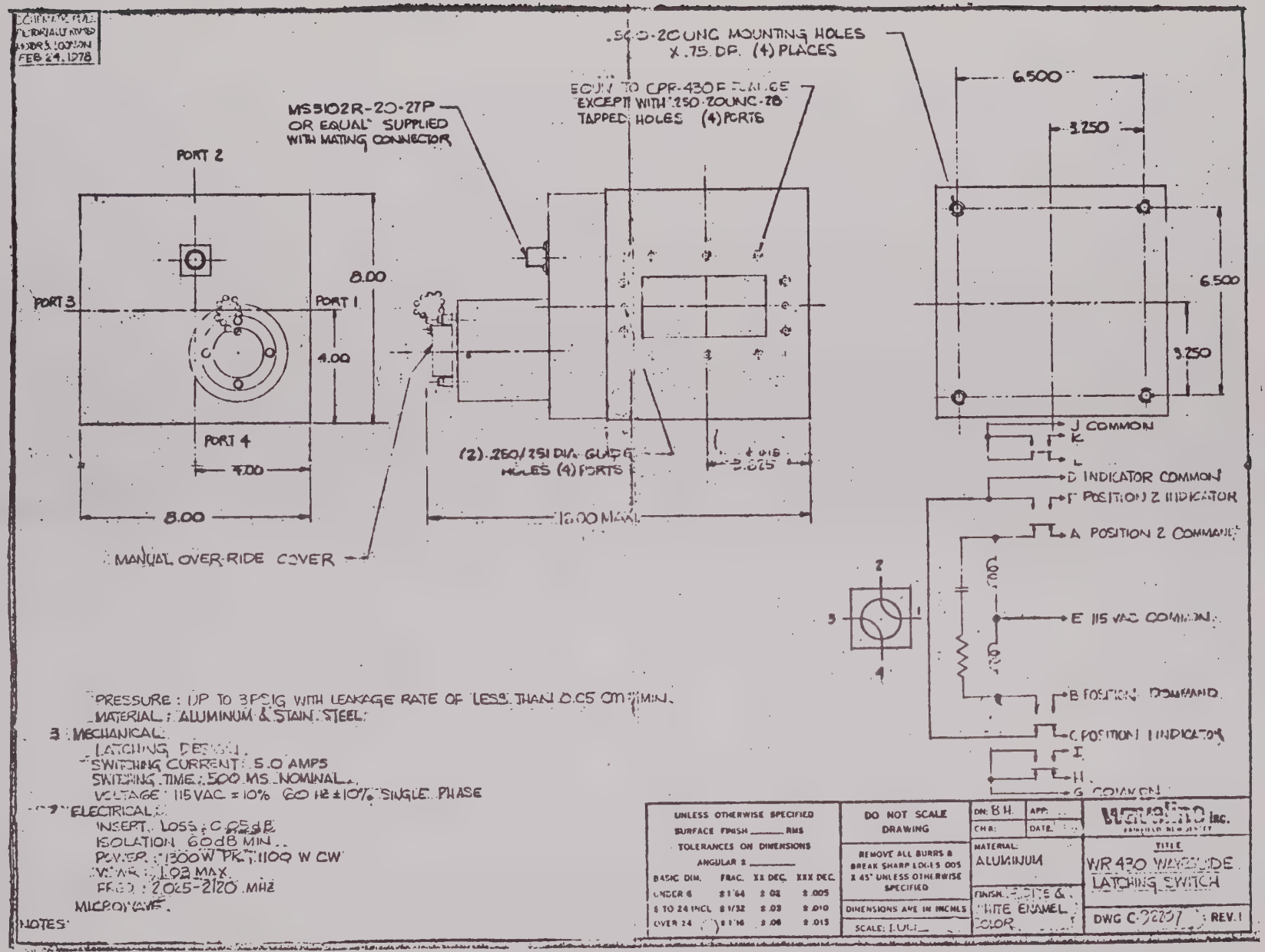


Figure 1-4. WR430 Waveguide
Latching Switch

TABLE 1-1 MAJOR COMPONENTS

COMPONENT	REFERENCE SCHEMATIC	REFERENCE DESIGNATION	FIGURE REFERENCE	NASA MANUAL #	LOCATION
Azimuth Rotary Joint	159972	2A2A1A5	(157589)		Pedestal
Elevation Rotary Joint	159972	2A2A2A5	(157589)		Pedestal
Waveguide Switch	159971	2A3A5			Reflector Rear
RCP Diplexer	159971	2A3A1	(140498)		Reflector Rear
LCP Diplexer	159971	2A3A7	(140498)		Reflector Rear
Focal Point Feed Assembly	159971	2A3A4	(161900)		Reflector Focus
Paraboloidal Reflector			1-1		Reflector
Test Dipole Assembly	159971	2A3A6	(161900)		Reflector Vertex
RCP Preamp Enclosure	159971	2A3A2	(164415)		Reflector Rear
LCP Preamp Enclosure	159971	2A3A3	(164415)		Reflector Rear
2-Way Power Divider	159971	2A1A7			Base Extension

1.2.3 TRANSMIT/RECEIVE DIPLEXERS. The transmit signal paths proceed from the waveguide switch via WR430 waveguide to the transmit receive diplexers as shown in Figure 1-5. These are fixed tuned waveguide devices 75 inches in length, located at the rear of the reflector.

1.2.4 PARABOLOIDAL REFLECTOR. The 14-foot diameter reflector is a 24-panel structure with rear hub and radial panel support members; see Figure 1-1. A quadripod spar assembly attaches to the reflector assembly at fixed tabs located on the periphery of the reflector.

1.2.5 FOCAL POINT FEED ASSEMBLY. Figure 1-6 shows the focal point feed assembly, which is a cylindrical sealed housing containing the transmit/sum and difference channel radiators and associated components as described in greater detail in Section 1.3 of this manual.

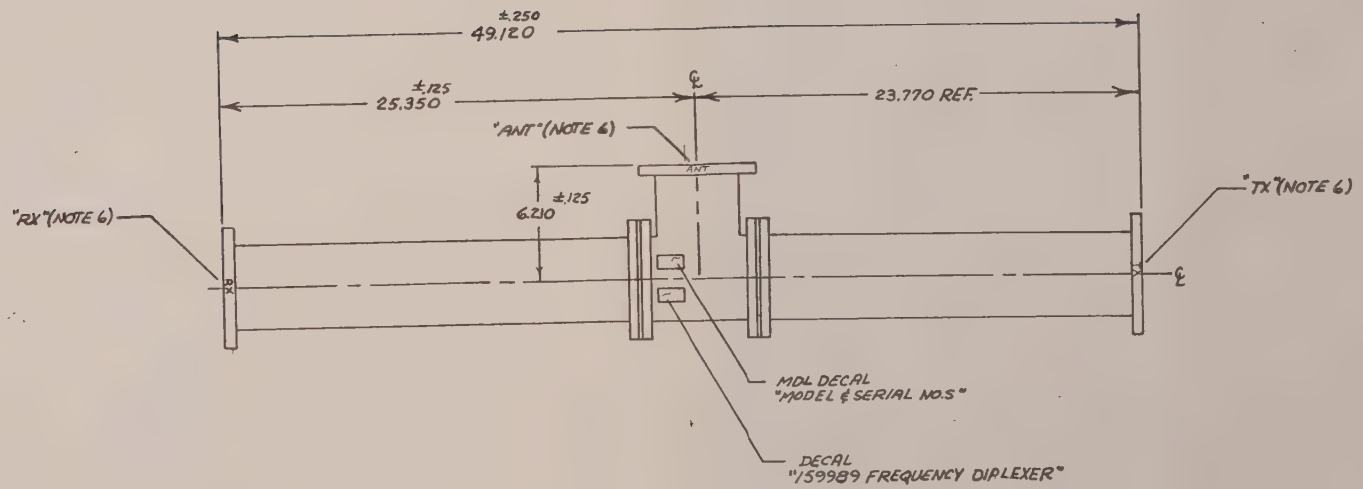
1.2.6 TEST DIPOLE ASSEMBLY. The vertex dipole assembly employed in transmitter monitoring is a single element dipole, as shown in Figure 1-7.

1.2.7 PREAMP ENCLOSURES. The six channels for RF output from the monopulse feed are routed via ½" air-dielectric coaxial cables to the preamp enclosures located at the rear of the reflector. Each enclosure is a sealed unit housing bandpass filters, test-injection power dividers and couplers, and RF amplifiers as shown in Figure 1-8.

1.2.8 TWO-WAY POWER DIVIDER. The two-way power divider for monopulse test injection is located near the foot of the base extension; see Figure 1-1.

1.3 FUNCTIONAL DESCRIPTION

Figure 1-9 is an overall block diagram of the Antenna Group. The functional description presented in this section follows the RF path; from the transmitter interface to the antenna aperture to the GFE downconverter interface for the receive and monopulse tracking mode.



NOTES:

1.0 BASIC MATERIAL: ALUMINUM ALLOY 6061, WR-430.

2.0 ALL FLANGE TERMINATIONS TO BE MIL-F-3922/52-006 OR EQUIVALENT.

3.0 PARKER SEALS #5906-430-1 (2 PLACES).

4.0 PRESSURE: 5 PSIG DRY AIR OR NITROGEN WITH A LEAKAGE RATE 1.0 LB/HR.

5.0 FINISH: INTERIOR AND FLANGE FACES IRIDITED PER MIL-C-5541 CLASS 1A.

EXTERIOR SURFACES: WASH PRIMER PER MIL-P-15328, ONE COAT ZINC-CHROMATE PRIMER PER FEDERAL SPEC. TT-P-1757, ONE COAT WHITE ALKYD GLOSS ENAMEL PER FEDERAL SPEC. TT-E-489C.

6.0 MARKING: IDENTIFY PORTS AS SHOWN BY METAL STAMPING IN 1/8 HIGH CHARACTERS.

REFERENCE: SCIENTIFIC ATLANTA, INC. SPEC. #159989.

Figure 1-5. Frequency Diplexer

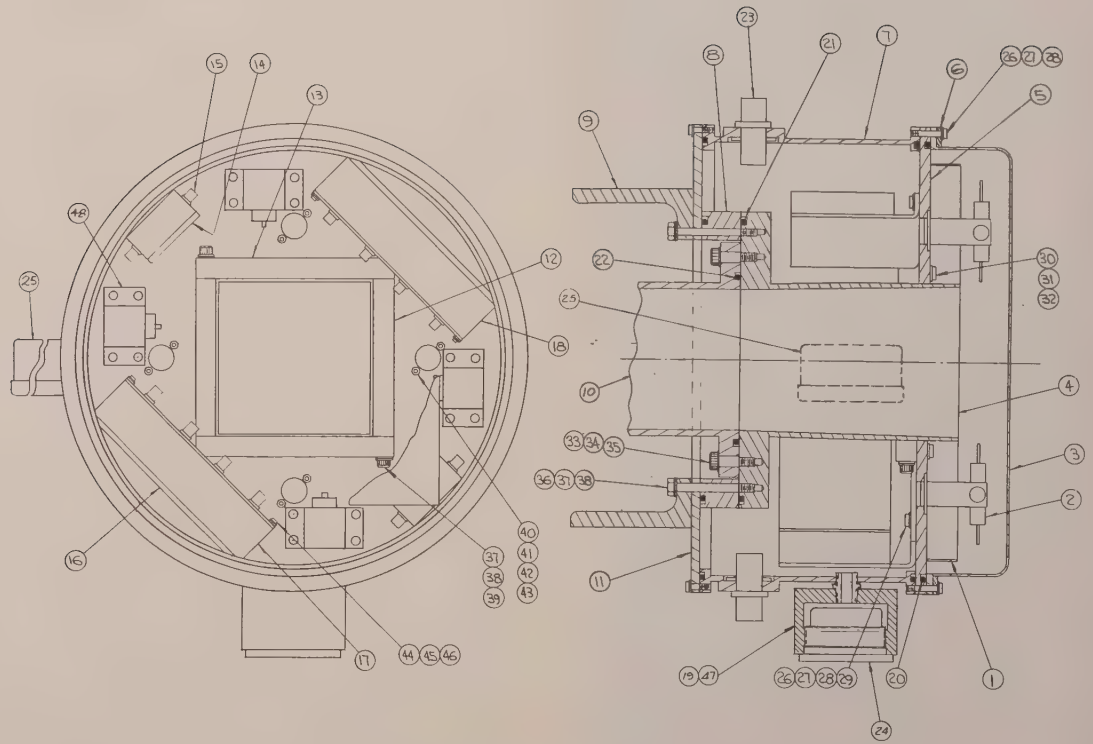


Figure 1-6. Feed Assembly

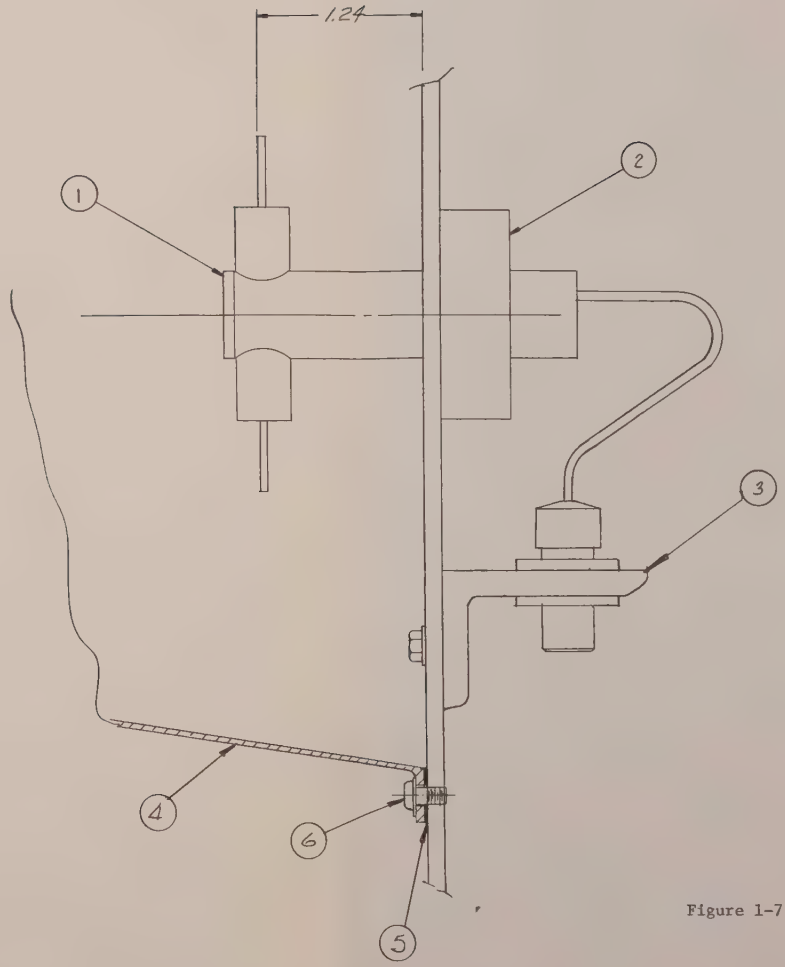
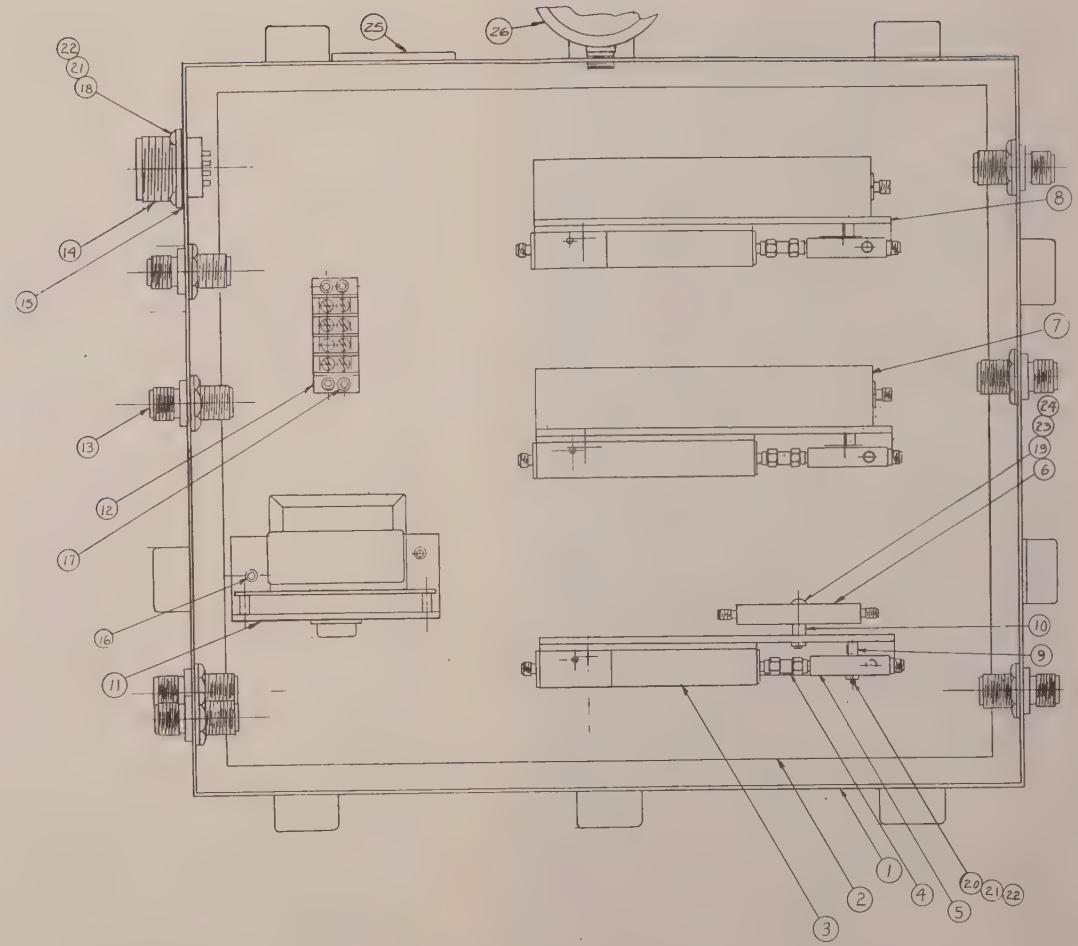


Figure 1-7. Assembly, Vertex Dipole



1. OMNI-SPECTRA/AMERICAN 140 4TH AVE. W., WALTHAM, MA.
2. ELECTRO STATICS 7718 CLAIRMONT MESA BLVD, SAN DIEGO, CALIF.
3. AGM CORGO TIES, INC. P.O. BOX 6089 TUCSON, ARIZONA 85716
4. MARSH INSTRUMENT CO. SKOKIE, ILL

Figure 1-8. Assembly, RF Box

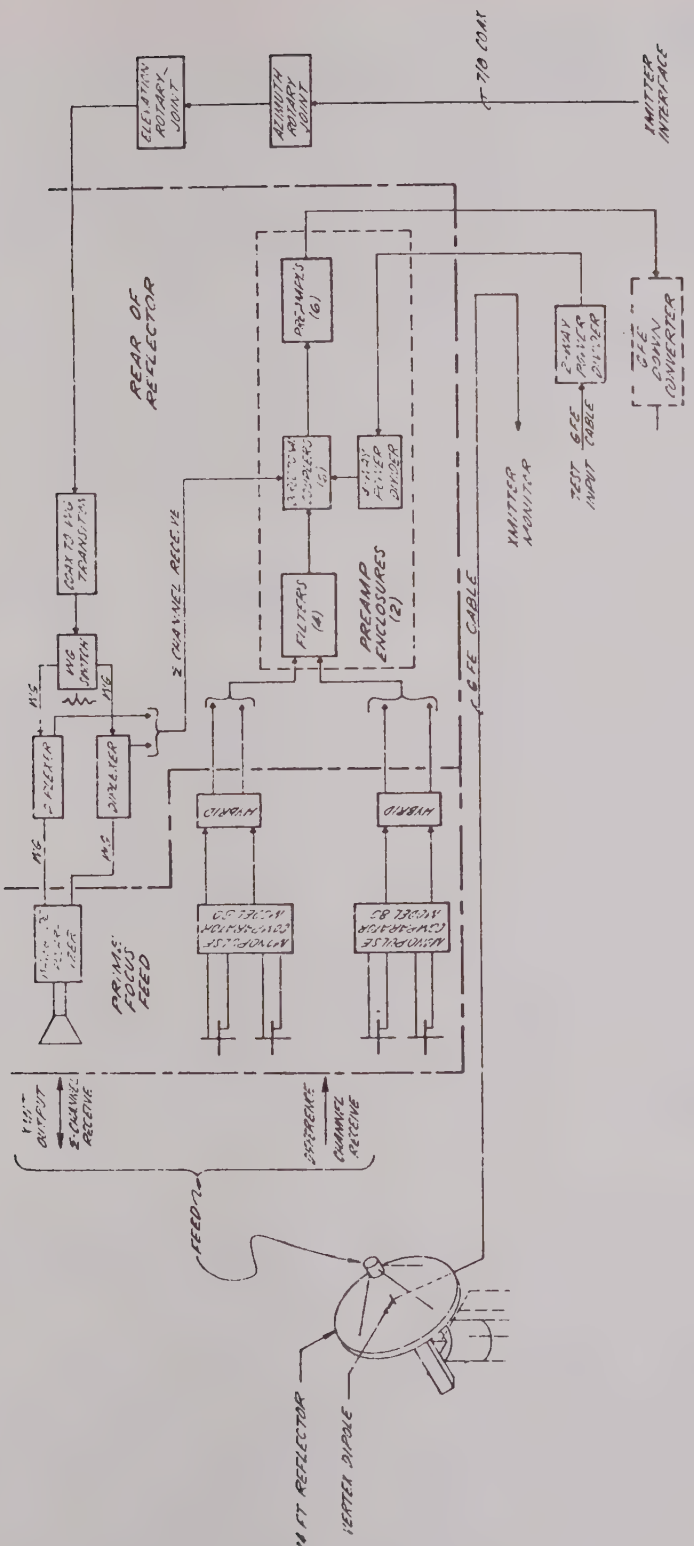


Figure 1-9. Overall Block Diagram of Antenna Group

1.3.1 TRANSMIT COAXIAL INPUT CIRCUIT. The GFE transmitter input interfaces with the S-Band Monopulse Antenna System at a 7/8" EIA connector located on the base extension supporting the pedestal assembly. A pressurized 7/8" coax run passes through the pedestal via rotary joints at the azimuth and elevation axes of the pedestal, and up to the polarization select waveguide switch located at the rear of the reflector.

1.3.1.1 COAXIAL ROTARY JOINTS. The azimuth and elevation rotary joints are identical non-contacting coaxial units designed for transmission of S-Band RF signals over the 2025-2120 MHz band. The TEM RF path is in-line with the mounting flange, and includes choke type rotating junctions. The units are rated for speeds and accelerations up to 20^{o}/second and 10^{o}/sec/sec respectively, and for pressurization to 3 psig with maximum pressure leakage of 0.10 cm^{3}/minute.

1.3.2 TRANSMIT POLARIZATION - SELECT SWITCH. The 7/8" transmit line interfaces with the polarization - select switch via a 7/8" EIA to WR430 adapter, which launches a TE_{10} wave in the input port of the four-port switch. The switch is a latching device acting as a DPDT transfer switch, where the input wave is routed either to the RCP or LCP output WR430 port while the unused output port is connected to the fourth switch port. The fourth port is terminated via a WR430 to type "N" adapter and coaxial load. Commands (latching signals) are provided to the switch remotely from a control unit located in a GFE rack. A separate unit manual is provided for the polarization control unit.

1.3.3 TRANSMIT/RECEIVE DIPLEXERS. The RCP and LCP outputs of the 4-port switch are routed via WR430 waveguide to identical waveguide diplexers located at the rear of the reflector. Each diplexer consists of a tee-junction and two waveguide band pass filter arms. The transmit filter is centered at 2072.5 MHz, and the receive filter at 2250 MHz. Tuning and phasing of the filter arms in relation to the tee establishes minimum isolations of 120 dB transmit-to-receive and 35 dB receive-to-transmit. The transmit outputs interface with WR430 waveguide for routing to the feed assembly, while the receive outputs interface with WR430 to coaxial adapters for coax line routing

to the preamp enclosures. Full technical specifications for these units are presented in Section 1.4.4 of this manual.

1.3.4 PARABOLOIDAL REFLECTOR. A solid-surface multi-panel aluminum paraboloidal reflector of 14-foot diameter and 6-foot focal length is employed in the system. This reflector collimates the primary transmit wavefront radiated by the prime-focus feed horn, producing a directive secondary radiation pattern. On reception, the portion of incident wavefronts intercepted by the reflector aperture is focused on the feed aperture. Full technical specifications for the reflector are presented in Section 1.4.2 of this manual.

1.3.5 FOCAL POINT FEED ASSEMBLY. The feed assembly includes a waveguide dual-circular polarizer and pyramidal horn in the transmit/sum-receive path, and dual-circular crossed dipole/comparator/hybrid circuits in the difference channel path. The dipole arrays are located symmetrically around the periphery of the axial horn aperture. Technical specifications for the feed/reflector assembly are presented in Section 1.4.1 of this manual.

1.3.5.1 TRANSMIT/SUM-RECEIVE POLARIZER. The waveguide polarizer employed in this feed is a dual input sloped-septum polarizer unit. Viewed as a transmitting device, the input ports are WR430 waveguide, excited by the selected RF path from the previously discussed diplexers. The input TE_{10} wave traverses an E-plane bend into the sloped-septum transition section and exits as a multimode wave in square waveguide, comprising essentially orthogonal TE_{10} components phased for either RCP or LCP radiation.

1.3.5.2 TRANSMIT/SUM-RECEIVE HORN. The polarizer square guide port interfaces with a pyramidal horn flare section of optimum square aperture for the 0.43 F/D of the reflector. The phase center of this horn is nominally constant, near the horn aperture, over the full transmit-receive bandwidth. The horn is stationed on the focal line and focused at the optimum separation from the reflector by means of antenna range measurements.

1.3.5.3 DIFFERENCE - RECEIVE DIPOLE ARRAY. Difference channel signals are produced on reception by a set of four cavity-backed crossed dipole elements with dual-linear outputs, feeding eight component phasors into the hybrid-tee comparator circuits. The dipole elements are located symmetrically about the flats of the axial horn aperture described above, at distances from the axis in accordance with the required crossover level for the monopulse difference patterns. This arrangement results in an equivalent set of four squinted secondary lobes yielding an amplitude-sensing monopulse difference function.

1.3.5.4 MONOPULSE COMPARATORS. Proper phase and amplitude combinations of the dipole signals within the comparators yield orthogonal linear sets of azimuth and elevation difference signals. This function is accomplished via a set of hybrid - tee junctions in stripline format, yielding Δ EL/H, Δ EL/V, Δ AZ/H and Δ AZ/V signals and the corresponding set of sum signals. The Δ signals are routed to the polarization hybrids discussed below, while the Σ signals are terminated in matched coaxial loads.

1.3.5.5 DIFFERENCE CHANNEL HYBRIDS. Proper phase adjustment of the coaxial lines connecting the comparators and difference channel hybrids, which are 90° stripline units, provides for combination of the Δ EL/H and Δ EL/V comparator outputs thourgh the elevation hybrid to produce Δ EL/RCP and Δ EL/LCP outputs, and similarly for the azimuth set.

1.3.6 VERTEX DIPOLE TRANSMIT TEST ASSEMBLY. A single-element dipole/ground-plane assembly is permanently mounted at the vertex of the reflector. This dipole extracts a sample signal from the primary illumination wavefront radiated by the transmit feed horn. The associated monitor cable and transmitter monitor are GFE items.

1.3.7 MONOPULSE PREAMP ENCLOSURES. The six receive-channel signals (Σ /RCP, Σ /LCP, Δ EL/RCP, Δ AZ/RCP, Δ EL/LCP, Δ AZ/LCP) are routed via individual coaxial lines to the preamp enclosures located at the rear of the reflector. The Δ signals are derived as described in paragraphs 1.3.5.3 - 1.3.5.5, above; the Σ signals are derived from the central

feed horn and polarizer via the diplexers described in paragraph 1.3.3 above. The preamp enclosures are identical, one serving the RCP path and one the LCP path.

1.3.7.1 DIFFERENCE - CHANNEL FILTERS. The two identical difference - channel filters in each enclosure are RF bandpass units with a passband of 2200 - 2120 MHz. Full technical specifications for these filters are presented in paragraph 1.4.3 below.

1.3.7.2 DIRECTIONAL COUPLERS. The four filtered difference signals and the two sum-receive signals all pass through the through arms of Narda stripline 20 dB couplers. These couplers are employed in test-injection exercises for the monopulse circuitry.

1.3.7.3 FOUR-WAY POWER DIVIDER. Inputs to the coupled arms of the test injection couplers are provided via a 4-way power divider, which is in turn input from the 2-way divider discussed below. Three outputs are used from each 4-way divider; the unused outputs are terminated in matched coaxial loads.

1.3.7.4 PREAMPLIFIERS. The three transistor receive-band preamps in each enclosure are identical 2200 - 2300 MHz units with continuously adjustable gain over the 20 dB to 35 dB range. Each set employs a common dc power supply, also located in the enclosures. Full technical specifications for the preamps are presented in Section 1.4.5 below.

1.3.8 MONOPULSE TEST 2-WAY POWER DIVIDER. The interface for single-line test signals from GFE test circuitry is the 2-way power divider located in the base extension of the pedestal. Each of the outputs is routed via coax cable to the associated RCP or LCP test-injection 4-way divider in the RCP or LCP preamp enclosure.

1.4 CONDENSED DATA

This section includes tabulations of technical characteristics for the major components of the Antenna Group.

1.4.1 REFLECTOR AND FEED SPECIFICATIONS

Table 1-2. Reflector and Feed Characteristics

Characteristic	Specifications
Capabilities	Transmission; Monopulse Reception
Configuration	14-foot-diameter paraboloid; prime-focus feed assembly; quadripod mount.
Frequency of Operation	Transmit: 2025 - 2120 MHz Receive: 2200 - 2300 MHz
Polarization	Transmit: Selectable RCP or LCP Receive: Dual RCP and LCP; Σ, ΔEL and ΔAZ
Gain	Transmit: 35.0 dB minimum above a circularly polarized isotropic reference, referenced to the input port of the polarization select switch Receive: 36.0 dB minimum above a circularly polarized isotropic reference, referenced to the preamp inputs.
Half-power Beamwidth	Transmit: 2° to 3° for either RCP or LCP Receive: 1.8° to 2.8° for the Σ pattern for both RCP and LCP.
Sidelobes to 90°	Transmit: 15 dB minimum below the main lobe peak level. Receive Σ : 13 dB minimum below the Σ pattern peak level.

Characteristic	Specification
Sidelobes beyond 90°	Transmit and Receive: 35 dB minimum below the beam peak level.
Null Depth	25 dB minimum below the Δ pattern lobe peak level.
Δ Signal Amplitude Balance	0.4 dB maximum imbalance referenced to preamp inputs
VSWR	Transmit port: 1.3 max Δ ports: 1.5 max Σ ports: 1.3 max
Δ Channel Cross Coupling	15% maximum for angular offsets ≤ 0.5 times the Σ 3 dB BW, in the vertical and horizontal planes.
Σ-to-Δ Level	Δ peak levels ≤ 6 dB below related Σ peak level
Cross-Polarization/Cross-Error Channel Lobes	12 dB minimum below the copolarized coplanar channel level
Axial Ratio	2.0 dB maximum; either CP mode; transmit & receive.
RF Power Handling (Transmit)	500 watts CW; 600 watts peak

1.4.2 14-FOOT REFLECTOR SPECIFICATIONS

Table 1-3 Reflector Characterisitcs

Characteristic	Specification
Type	Paraboloidal Reflector
Construction	Central Hub; 24 panels
Diameter	14 feet
f/D	0.43
Axial Length (with feed)	133 inches
Feed Support	Quadripod and 3-dimensional adjust

1.4.3 DIFFERENCE-CHANNEL FILTER SPECIFICATIONS

Table 1-4 Filter Characteristics

Characteristic	Specification
Frequencies	Pass-Band 2200-2300 MHz Stop-Band 2025-2120 MHz
Pass-Band Ripple	Less than 0.2 dB
Pass-Band Insertion Loss	2 dB maximum
Stop-Band Insertion Loss	120 dB minimum
VSWR	1.5 maximum
Receive/Transmit Group Delay	Maximum slope ± 10 ns/MHz over Pass-Band
Stop-Band Shape Factor	60 dB-down BW $\leq$ 2 times the 3-dB-Down BW
Symmetry	1-db-down and 3-dB-down BW symmetrical about 2072.5 MHz.
Phase Delay Linearity	Nonlinearity $\leq$ ± 10% rad/sec/MHz to the 1-db-down level in the Pass-Band
Differential Phase Shift (between filters)	$\leq$ 10° phase
Characteristic Impedance	50 ohms
Power Handling	500 watts CW for 8 hours at 2072.5 MHz

1.4.4 TRANSMIT/RECEIVE DIPLEXER SPECIFICATIONS

Table 1-5 Diplexer Characteristics

Characteristic	Specification
Frequencies	Transmit: 2025 - 2120 MHz Receive: 2200 - 2300 MHz
Insertion Loss	Transmit: 0.2 dB max Receive: 0.5 dB max
Insertion Loss Ripple	0.2 dB max, peak-to-peak
Isolation	Transmit/Receive 120 dB min Receive/Transmit 35 dB min

Characteristic	Specification
VSWR (all ports)	1-1 maximum
Power Handling (Transmit)	500 watts CW; 600 watts peak
Receive/Transmit Group Delay	Maximum slope ± 10 ns/MHz over Pass-Bands
Phase Delay Linearity	Nonlinearity≤±10% rad/sec/MHz to the 1-dB-down levels in the Pass-Bands.
Stop-Band Shape Factors	60-dB-down BW≤2 times the 3-dB-down BW
Symmetry	1-dB-down and 3-dB-down BW's symmetrical about 2072.5 MHz (Transmit) and 2250 MHz (Receive).
Differential Phase Shift (between diplexers)	±10° phase maximum
RFI	Maximum radiation - 150 dBm with 600 watts peak applied at transmit port.

1.4.5 PREAMPLIFIER SPECIFICATIONS

Table 1-6 Preamplifier Characteristics

Characteristic	Specification
Frequency Band	2200 - 2300 MHz
1 dB Bandwidth	100 MHz
Noise Figure	3.0 dB maximum
Gain	20 dB to 35 dB; continuous screwdriver adjust
VSWR (ref. 50 ohms)	1.5 maximum; input and output
Phase Linearity	Within ±5° of best straight-line fit of phase vs. frequency curve between 1 dB BW points
Delay Distortion	0.1 nsec/MHz max; approx. symmetrical parabolic characteristic
Differential Phase Shift (between preamps)	±10° phase maximum over 1 dB BW.
Absolute Phase Stability	±5° max for 12 hours for -20° F to +100°F. Operational (degraded) for -30°F to +135°F.
Pass-Band Ripple	0.5 dB max peak-to-peak over 1 dB BW

Characteristic	Specification
Absolute Gain Stability	±1 dB maximum (6 hours over full environment)
1dB Gain Compression	-30 dBm input; all specs apply up to this input level.
Side-by-side isolation	50 dB minimum
Spurious Output	60 dB minimum below desired response for input level up to -30 dBm
Intermod Products	60 dB minimum below output of 2 signals at levels of -50 dBm.

1.4.6 TEST INJECTION NETWORK SPECIFICATIONS

Table 1-7 Test Injection Characteristics

Characteristic	Specification
Frequency Band	2200 - 2300 MHz
Final Injection	20 dB Coupler
Insertion Loss (Through Arm)	0.3 dB maximum
Coupling Factor	28 dB maximum
Coupling Losses (including 250 feet of RF cable)	40 dB maximum
Isolation (Channel-Channel)	50 dB minimum
Output Amplitude Balance	± 1 dB maximum between 6 outputs

SECTION 2. INSTALLATION

2.1 GENERAL

This section contains suggestions and factors to consider before installing. Close adherence to these suggested procedures will assure a more satisfactory performance.

2.2 UNPACKING AND INSPECTION

Exercise due caution when unpacking units. Carefully open each carton and inspect for shipping damage. If a claim for damage is made, save the packing material and carton to substantiate the claim. File the claim with the carrier and notify the local Scientific-Atlanta sales representative immediately. Do not return the unit until shipping instructions have been received from the factory.

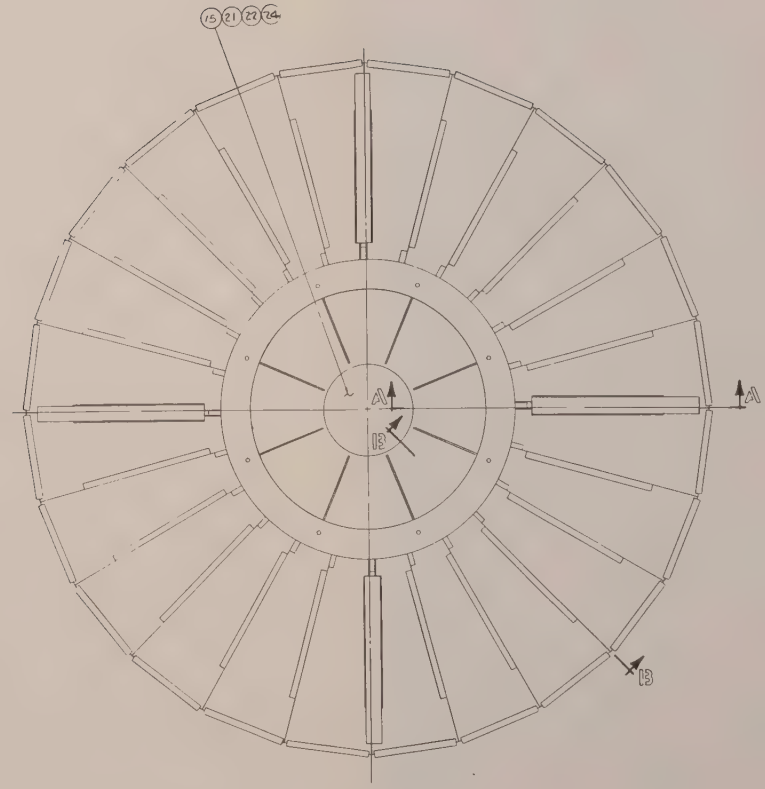
After all units have been removed from shipping cartons and inspected, check all packing for small components that may have been wrapped separately, and compare the units received with the packing list. If possible, replace all packing material in the cartons and save for future storage and/or reshipment.

2.3 INSTALLATION

2.3.1 ASSEMBLY OF REFLECTOR. Refer to Figure 2-1 exclusively for the following procedure.

(1) Check to see that all hardware specified on Figure 2-1 with respect to size and quantity, has been received, and organized into separate groups for ready use.

(2) Account for, and become familiar with, all the parts, observing that certain parts are match marked for correct fit.



NOTE:
1. REFER TO DRAWING 161983 WHEN DISASSEMBLING REFLECTOR.

Figure 2-1. Reflector Assembly, 14-Foot Diameter
(sheet 1 of 3)

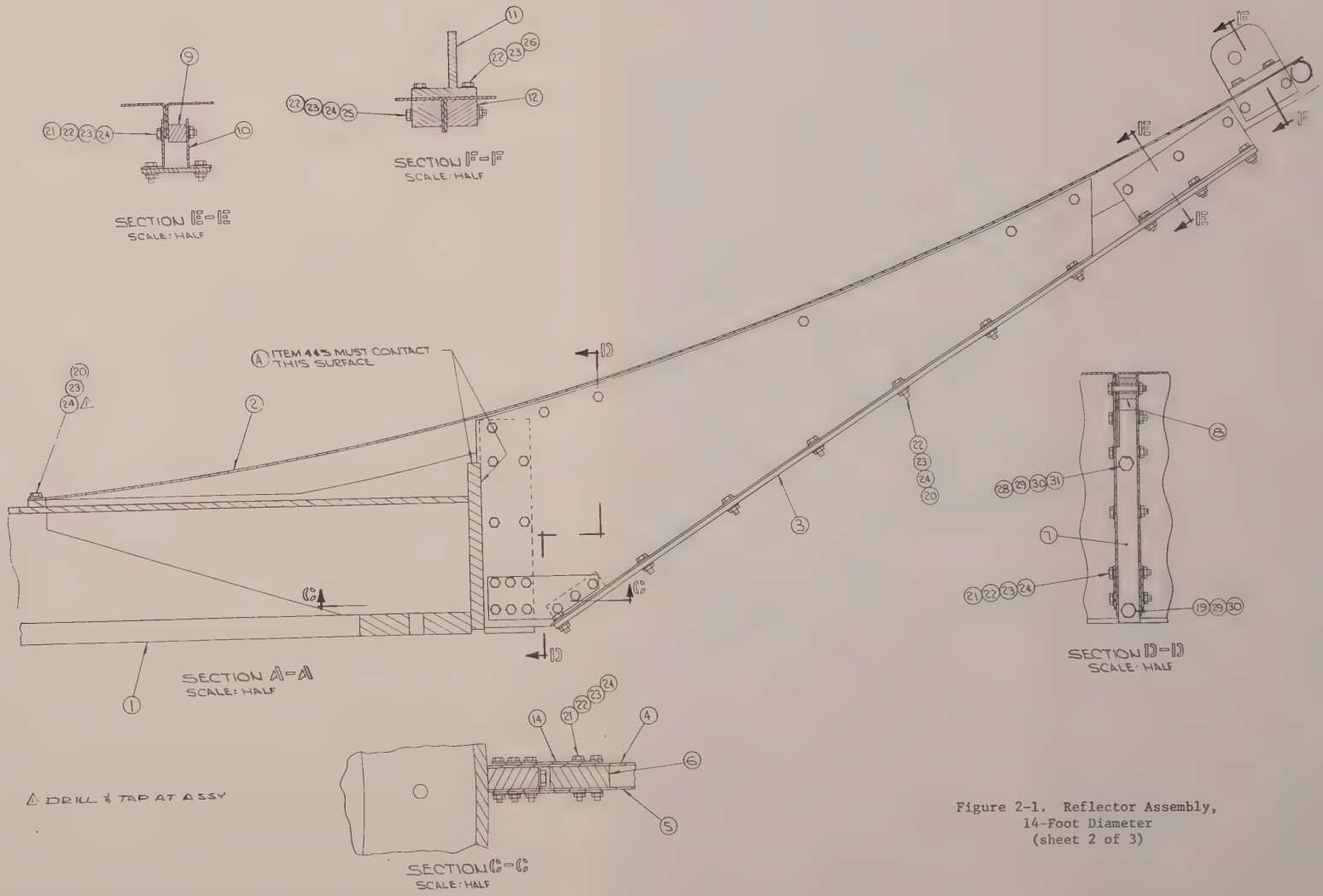


Figure 2-1. Reflector Assembly, 14-Foot Diameter (sheet 2 of 3)

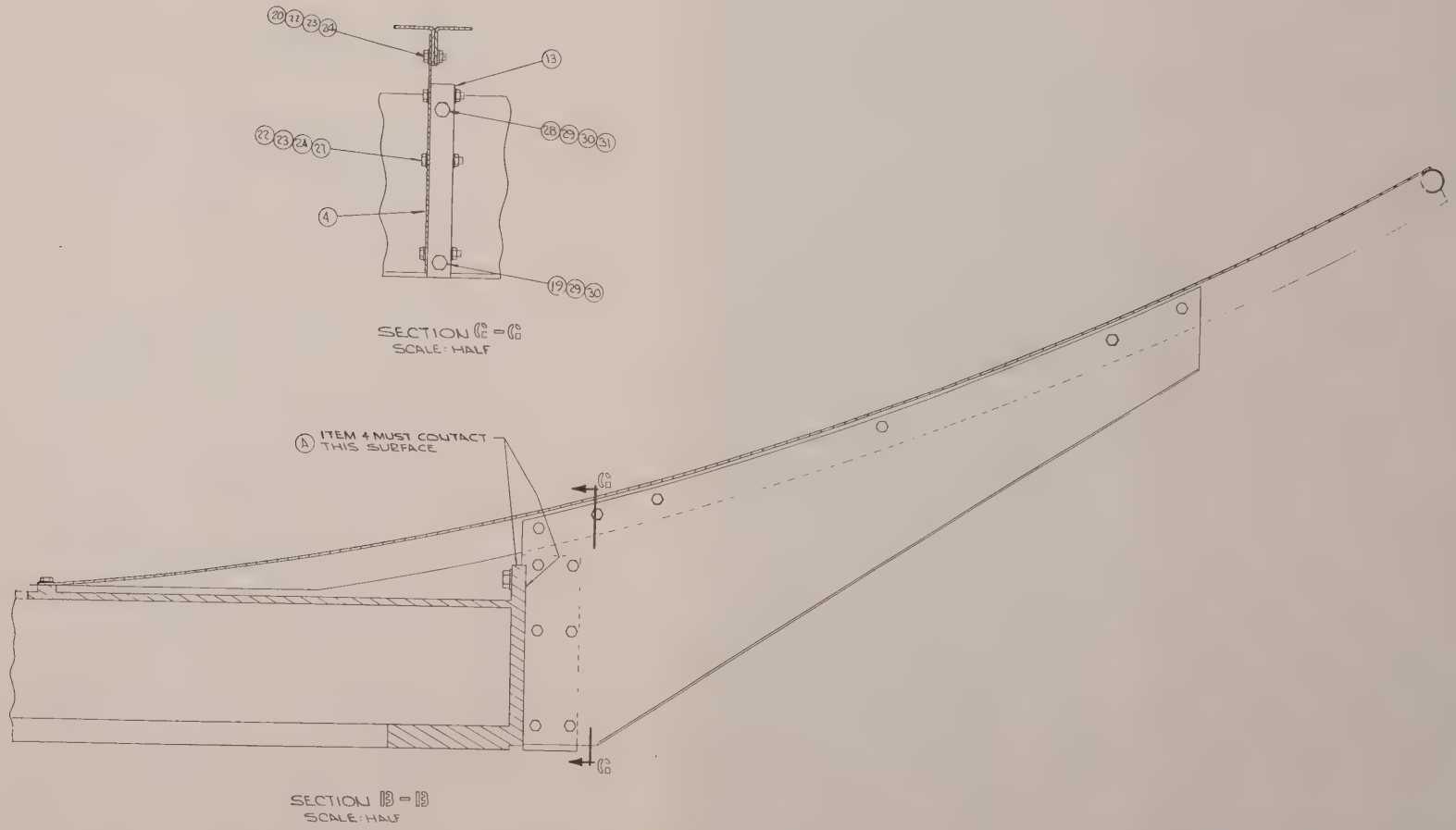


Figure 2-1. Reflector Assembly, 14-Foot Diameter (sheet 3 of 3)

Note

Since three systems are involved, each will have its own coding. System 1 will have all parts marked 1-XX, System 2 will be 2-XX, and System 3 will be 3-XX. The System must not become intermixed.

(3) The reflector assembly will be performed in an upright configuration, as if it were pointing straight up.

(4) Place the hub, item 1, on a suitable support, preferably one that will elevate it between 18 and 24 inches.

(5) The mounting blocks, item 7, are shipped attached to the hub and no further assembly needs to be performed with them.

(6) The four sets of spar attachment panels are installed on the reflector first. These units consist of two panels fastened together and shipped as a sub-assembly. It will be noted they have been match marked for positioning on the hub. The match marks on the hub and panels must coincide for proper reflector assembly and performance.

(7) Fasten these four sets of panels to the reflector at their proper locations, using specified fasteners. The panel supports must firmly contact the outer ring of the hub. See Section A-A, sheet 2.

(8) Fasten the panel supports, item 4, to the unused mounting blocks of the hub. Care must be exercised to locate them against the proper surface of the blocks. Secure in place with the specified hardware, being certain they firmly contact the outer ring of the hub. See Section B-B, sheet 3.

(9) The hub is now ready to receive the remaining 16 panels. Locate them with the match marks on the hub and panels aligning. Fasten the panels in place using the specified hardware, but do not tighten until all are in place.

(10) After all the panels are in place, tighten the attaching fasteners.

This completes assembly of the reflector. It is now ready to receive the spars and feed.

2.3.2 SPAR AND FEED ASSEMBLY. Refer to Figure 2-2 for the following procedures.

(1) The feed assembly, together with the feed mounting ring and adjusting brackets, will be calibrated, bolted and pinned together, and shipped as a single unit. Disassembly is not recommended.

(2) The four mounting surfaces of the feed mounting ring will be match marked with a number that corresponds to the proper spar. Using this as a guide, position the spars at their proper position on the ring, and attach with the specified hardware.

(3) Lift the feed assembly with spars attached and place it over the assembled reflector. Observe that the 4-spar attachment blades on the reflector have been match marked to correspond with the spars. When locating the spar against the attachment blade of the reflector be certain the center line of the spar passes over the seam of the two panels.

(4) With the spars in proper position, attach them to the reflector with the specified hardware.

This completes the assembly of the feed and spars. The reflector is now ready to be installed on the pedestal.

2.3.3 RF PARTS ASSEMBLY. Refer to Figure 2-3 exclusively for the following steps. This assembly procedure will be carried out with the reflector mounted on the pedestal. Therefore, the pedestal must be in place, ready to receive the reflector with the side arms pointing at zenith.

The following precautions must be taken during the assembly procedure.

The stow pins for both axes must be installed. All electric power to the pedestal must be removed - cables unplugged.

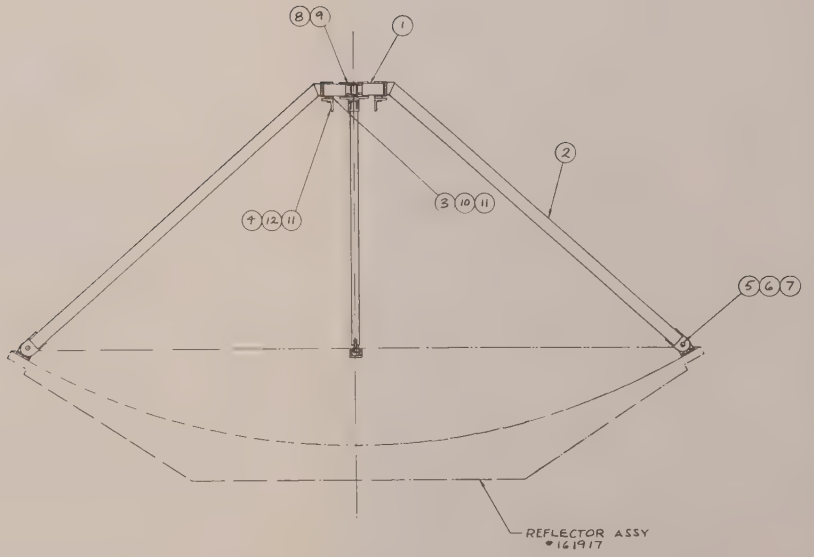


Figure 2-2. Spar Mounting Assembly

64	2	161954	WAVEGUIDE			
63	6		WASHER FLAT	1" SCDP		
62	6		WASHER, FLAT	3/8 SCDP		
61						
60	6		NUT, HEX	3/8-10UNC SCDP		
59						
58	6		SCREW, HEX HD	3/8-10 UNC x 4 LG SCDP		
57	6		SCREW, HEX HD	1"-8UNC x 8 LG SCDP		
56						
55	2	161948	BAR, SW SPACER			
54	1	161900	FEED ASSY			
53	1	161981	VERTEX DIPOLE ASSY			
52	2	86470	SOCKET, RELAY	8 PIN	27E122	PB
51	1	86781	JACK, PHONE	3 COND 3 WIRE	4-112B	JC
50	2		LATCH		07-10-101-11	94222
49	1	72900	EM DISABLE SW	250VAC, 10A, DPST	7561K4	CH
48	1	157595	COAX/WG ADP		DIC-351	01882
47	1		BASE, SCOPE		*85-1	⚠2
46	1		SCOPE	30x MAGNIF	*83	⚠2
45	1		TERMINATION		T350N	18203
44	2	71799	RELAY	115VAC DPDT, OCTAL	KRP11AG	PB
43	2		H PLANE ELBOW	45°	122.58	00443
42	1		AIR DRYER		MODEL 550	⚠1
41	2	140498	DIPLEXER		430DZP139	01456
40	1	157588	SWITCH		4377 E	00443
39	4		E PLANE ELBOW	90°	430BE14	01456
38	2		WAVEGUIDE TWIST	15 IN LG	4390-2	00443
37	4		H PLANE ELBOW	90°	430BH14A	01456
36	2		E PLANE ELBOW	45°	122.50	00443

35	A/R	80272	GASKET			
34	1	161960	MOUNT, SCOPE			
33	2	161961	HINGE, SCOPE COVER			
32	1	161959	COVER, SCOPE			
31	1	161962	MOUNT, SCOPE			
30	2	161963	MTG BAR, DRYER			
29	1	19673	COVER, ACCESS			
28	1	161958	COVER, ELECT			
27	1	161919	PRESSURE SYSTEM			
26	2	126497	COVER, CNIT ARM			
25	1	106884	POWER CONTROL			
24	1	162782	CONNECTOR PANEL			
23	2	140180	POWER AMP			
22	CIE		DOWNCONVERTER		M-7250	
21	1	84836	POWER DIVIDER	1GHz TO 2GHz	40256	ANE
20	3		COAX/WG ADAPTER	SEALED	LA-90-UAM	⚠3
19	2	164415	ENCLOSURE			
18	2	161946	MTG PLATE			
17	4	161945	MTG BRACKET			
16	6	161944	MOUNT, DIPLEXER			
15	1	161947	MTG BRACKET			
14	2	163874	WAVEGUIDE FLEXIBLE	12.92 LG		
13	2	161952	CLAMP			
12	2	161957	WAVEGUIDE			
11	2	161950	CLAMP			
10	2	161951	CLAMP			
9	2	161956	WAVEGUIDE			
8	2	161955	WAVEGUIDE			
7	2	124507	SIDE ARM			
6	6	64845	LEVELING FOOT			
5	1	161937	PEDESTAL ASSY			
4	26	126495	COUNTERWEIGHTS			
3	1	161916	SPARE MTG ASSY			
2	1	161917	REFLECTOR ASSY			
1	1	159242	BASE EXTENSION			

ITEM OR FIND NO.	QTY REQD	B.A. STOCK NO.	NOMENCLATURE OR DESCRIPTION	MATL SIZE OR VALUE	IDENTIFYING OR PART NO.	CODE IDENT

PARTS LIST

NOTE:

⚠1 GENERAL CABLE
5400 W. 88TH AVE.
WESTMINSTER, COLORADO 80030

⚠2 BRUNSON INSTRUMENT CO.
3500 E. 23RD ST.
KANSAS CITY, MISSOURI 64128

⚠3 MICROWAVE RESEARCH CORP
1429 OSGOOD ST.
N. ANDOVER, MASS. 01845

Figure 2-3. System Assembly
(sheet 1 of 4)

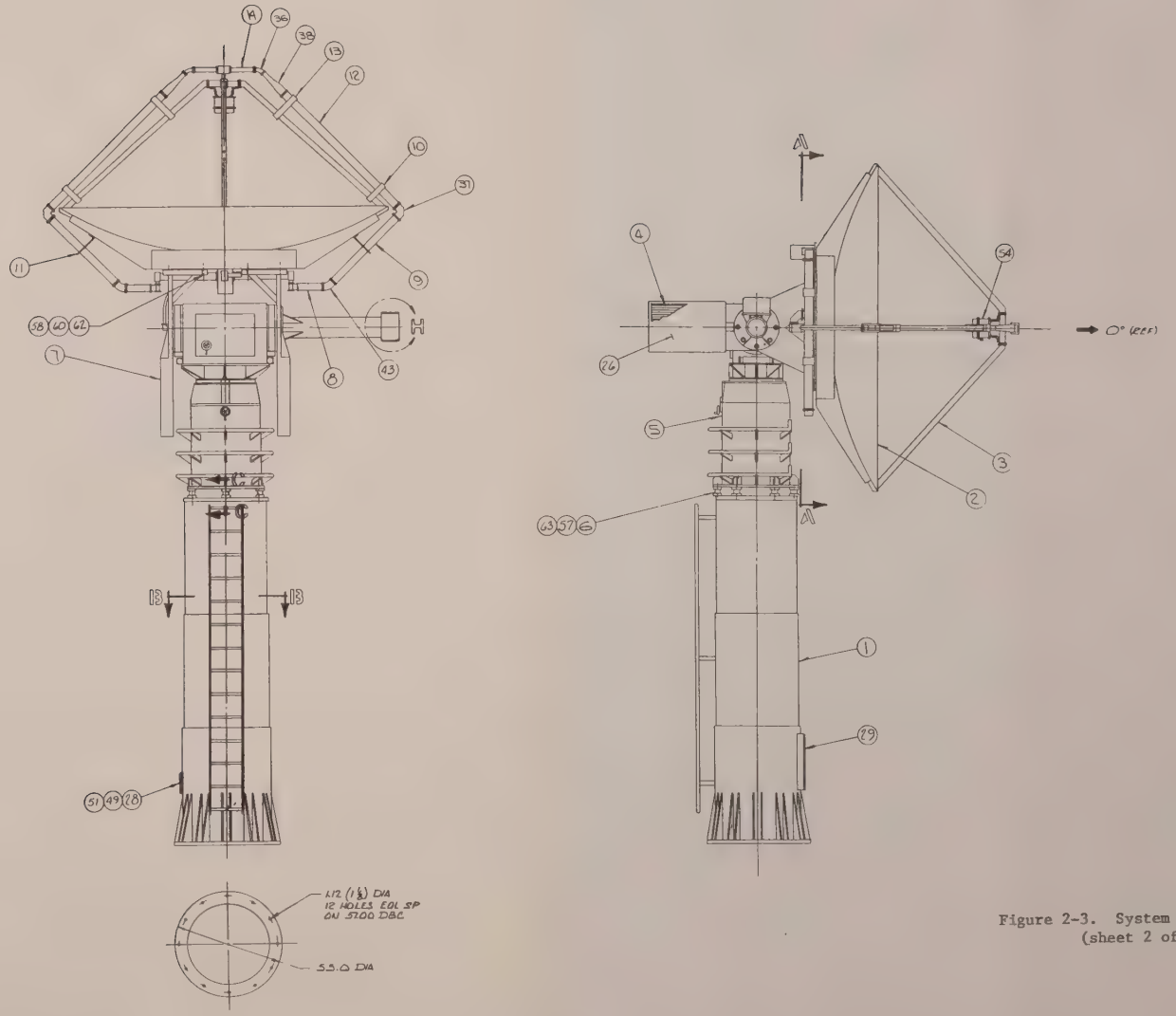
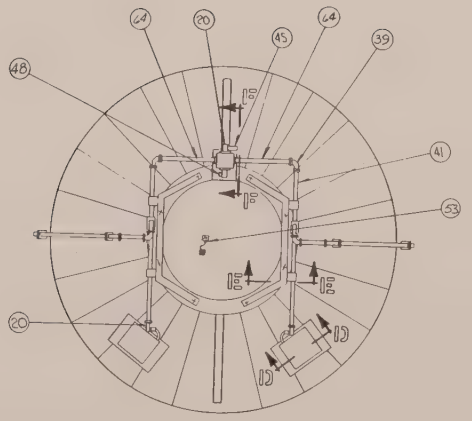
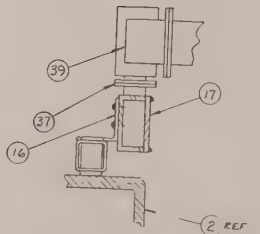
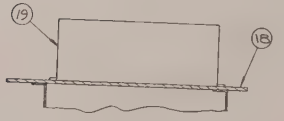


Figure 2-3. System Assembly
(sheet 2 of 4)







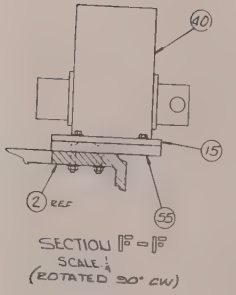
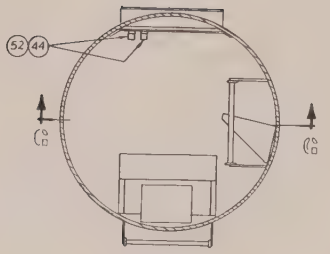
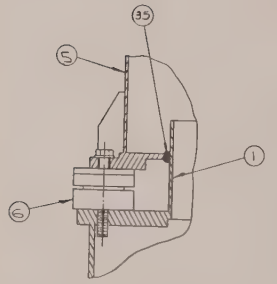
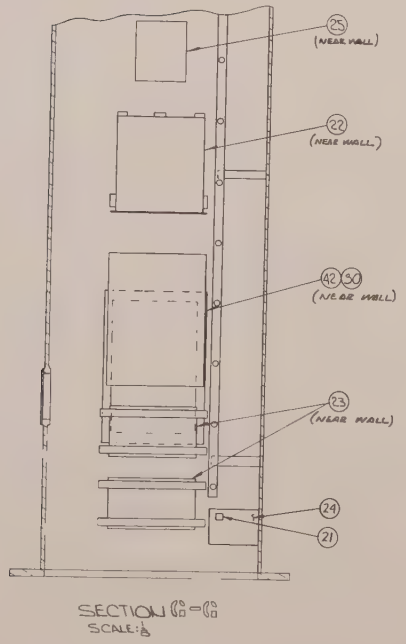
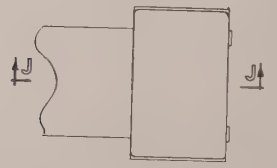


Figure 2-3. System Assembly
(sheet 3 of 4)









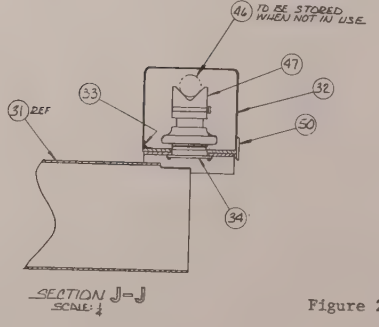


Figure 2-3. System Assembly
(sheet 4 of 4)

Installation of the reflector and all other work performed in the air must be with the use of an auxiliary man lift. The ladders were not designed as a means of installing either the waveguide or reflector.

(1) The reflector is lifted by attaching lifting straps or cables, to the four holes provided in the spar attachment brackets. The straps must be of sufficient length so as not to touch the feed assembly.

The reflector must be mounted with the match marks on the hub and sidearms of the pedestal coinciding. When properly positioned, fasten the reflector to the sidearms with the specified hardware.

Note

In some instances certain components will be shipped with mounting plates attached.

(2) Mount waveguide switch, item 40, to spacers, item 55. Refer to Section F-F, sheet 3.

(3) Mount the enclosures, item 19, to the reflector. Refer to Section A-A and Section D-D, sheet 3.

(4) Fasten waveguide mounting clamps, items 10, 12, and 13 to reflector. Refer to sheet 2.

(5) If the diplexer mounting brackets, item 16, are not attached to sidearms install them at this time.

(6) Place the diplexers, item 41, in their mounting brackets, item 16, then install cover, item 17. Be certain to position the diplexers with the TX port attaching to the waveguide switch and the RX part connecting to the coax adapter. Do not securely tighten the bracket screws at this time, the diplexer must be free to slide.

NOTE - WHEN INSTALLING WAVEGUIDE A SEAL MUST BE INSTALLED BETWEEN THE MATING FLANGES.

(7) Install waveguide, item 64, and elbow, item 39, between the switch and the diplexer. Again, be certain that this connects to the TX part of the diplexer.

(8) Attach elbow, item 37 to diplexer, then attach elbow, item 39, to this. Refer to Section E-E sheet 3.

(9) Install waveguide from the elbow at the diplexer to the feed. The waveguide must be supported by the mounting brackets as it is assembled. Do not permit the waveguide to be unsupported.

(10) Install the 7/8" diameter semi-rigid transmit coax cable through the pedestal to the waveguide switch. Observe that the cable connectors are brass and must mate with aluminum rotary joints and the coax waveguide adapter. To prevent galvanic corrosion the RF contact area on these brass connectors has been tin plated. No grease should be allowed on this surface since it will inhibit electrical conductivity. However, the "O" ring and the mating surface of the connector starting with the "O" ring groove and going outward should be given a light coating of silicone grease.

After installation is completed, the brass/aluminum joints can be further protected from corrosion by sealing them with "Conap" compound coating applied with a brush to the outside of the joint.

(11) Tighten all screws in mounting brackets that may have been left loose to permit assembly.

This completes the RF Assembly.

SECTION 3. OPERATION

3.1 GENERAL

With the exception of the selection of transmit polarization, there are no operating instructions and procedures unique to the Antenna Group of the S-Band Monopulse Antenna System. Refer to the system technical manual for discussions of the various system modes of operation.

Upon proper completion of the assembly and installation procedures delineated in Section 2 above, the Antenna Group comprises a pre-focused and pre-aligned subassembly. The feed focusing and alignment are as established in antenna range tests and reproduced at installation by means of matchmarks and rollpins.

Note

To assure optimum RF alignment, do not attempt to refocus or realign the feed system to correct for boresight errors which may be due to multi-path or malfunctioning components.

3.2 CONTROLS AND INDICATORS

The only control and indication function unique to the Antenna Group is the polarization selection for transmission. The Polarization Control Unit is mounted in a GFE equipment rack; operation of this unit is described in the system technical manual.

Energization of the preamp enclosures within the Antenna Group and of the GFE downconverter subassembly is via the RF Power on/off switch located on the Auxiliary Panel of the tracking subsystem console. Operation and indication for this function are also described in the system technical manual.

3.3 OPERATION

Operation of the Antenna Group falls within the scope of the system operational procedures. Refer to the system technical manual.

SECTION 4. THEORY OF OPERATION

4.1 GENERAL

This section presents the theory of operation of the Antenna Group by following the RF paths for the basic functions of transmission/sum-reception and difference-signal reception.

Figure 4-1 is an overall functional block diagram of the Antenna Group.

4.2 TRANSMISSION/SUM-RECEPTION OPERATION

The GFE transmitter interfaces with the Antenna Group at the base of the pedestal extension via an EIA 7/8 inch flange connector. The TEM transmit wave passes through the pedestal via 7/8 inch spirofil coax line with single-channel rotary joints at the azimuth and elevation axes, to a coax/WR430 adapter at the waveguide polarization switch input port is routed to either the RCP or LCP output port of the switch, and through WR430 waveguide to the transmit input port of the corresponding waveguide diplexer. The filter transmit TE, output from the selected diplexer is routed to the appropriate input port of the polarizer section of the feed assembly, and is converted to a multimode circularly polarized wave feeding the transmit/sum-receive horn centered on the reflector axis. The unused transmit path is terminated in a coaxial load at the fourth port of the polarization-select switch.

A transmit self-test capability is provided for by means of a transmitter monitor dipole mounted at the vertex of the reflector. The associated coax cable is routed through the pedestal axis cable wrap to the type N connector interface with a GFE subsystem.

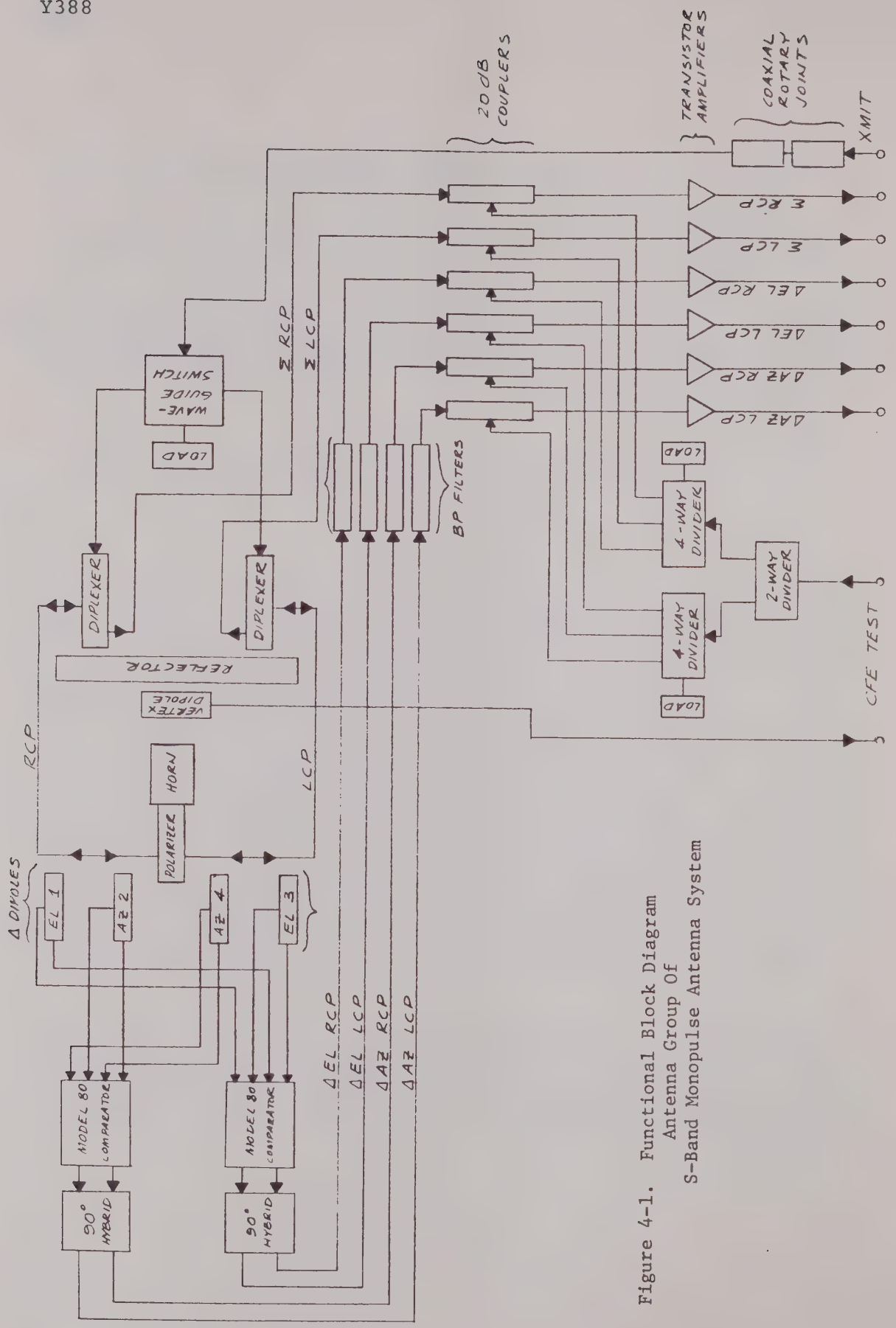


Figure 4-1. Functional Block Diagram
Antenna Group Of
S-Band Monopulse Antenna System

The telemetry and monopulse sum-signal reception function utilizes the same central feed horn, waveguide runs and diplexers mentioned above. The waveguide receive output port of each diplexer interfaces with a WR430 to type N adapter, from which the RCP and LCP sum signals are routed via coaxial line to the test-injection coaxial couplers in the preamp enclosures at the rear of the reflector.

The theory of operation for the major components of this portion of the antenna Group is presented in the following subsections.

4.2.1 COXIAL ROTARY JOINTS. The azimuth and elevation rotary joints are identical non-contacting coaxial units designed for transmission of S-Band RF signals over the 2025-2120 MHz band. The TEM RF path is in-line with the mounting flange, and includes choke type rotating junctions.

4.2.2 7/8-INCH COAX/WR430 Adapter. The coax/waveguide adapter converts the incident TEM wave arriving via the 7/8 inch coaxial line into a TE_{10} wave propagating into the input WR430 waveguide port of the polarization-select switch. An incident TEM guided wave in the coaxial line radiates into the waveguide section, with energy propagating both toward the waveguide output and toward the shorting plate terminating the waveguide cavity. The relative dimensions of the coaxial section outer diameter and center conductor and the waveguide cavity, coupled with dielectric loading in the coaxial section, transforms the wave impedance of the 50 ohm coaxial line into the appropriate WR430 waveguide impedance and produces constructive phasing of the reflected wavefront returning from the shorting plate. The resulting TE_{10} wave in the waveguide section propagates in the output direction, with low VSWR and essentially loss less transformation.

4.2.3 4-PORT POLARIZATION SELECT SWITCH. The polarization select switch is a solenoid actuated double-pole-double-throw unit, with internal waveguide bends in the E-plane. The stator of the unit is the waveguide housing, with all flange faces situated 90^{o} apart. The rotor of the unit effectively

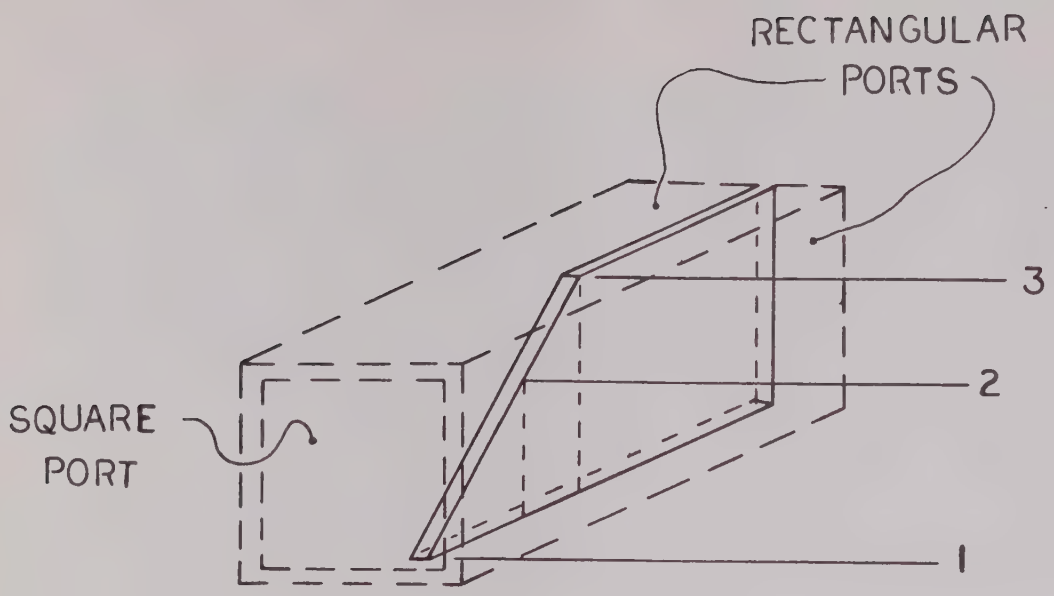
presents a shorting plate to connect alternate pairs of ports, using non-contacting choke sections for high isolation between desired RF paths.

This switch operates with a 28 VDC solenoid power supply, and is a fall safe design where low holding current maintains position #2 while a current-interrupt command or DC power failure returns the switch to position #1. Interlock features of the rotor circuitry provide rotor position indication signals.

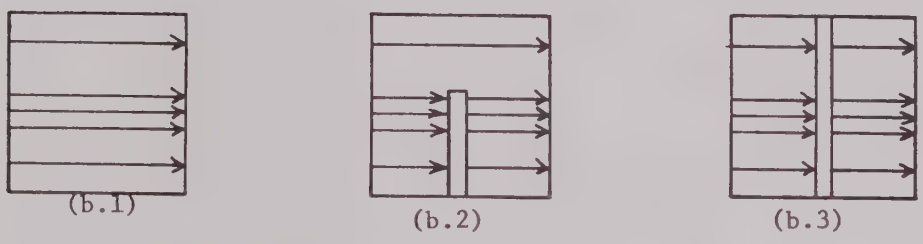
4.2.4 TRANSMIT/RECEIVE DIPLEXERS. The two identical waveguide diplexers consist of an H-plane tee junction whose common port is the antenna transmit/receive port of the device, and waveguide filter sections on the side-arms of the tee. Both filters employ successive direct-coupled resonant cavities reactively tuned at the center of the respective pass bands. Six sections are employed in the transmit filter arm, and thirteen sections in the receive filter arm. Out-of-band signals which reach the filter arms due to the finite directivity of the tee are fully reflected back toward the tee. Proper phasing, established via the dimensional design, yields additive combination of the desired signals and high isolation for undesired signals.

4.2.5 FEED POLARIZER SECTION. A dual-input sloped-septum power divider is employed as the polarizer section of the transmit/sum-receive feed horn. Figure 4-2(a) is a schematic representation of the septum area, showing the square guide horn interface, the sloped common broadwall septum, and the two rectangular guide ports.

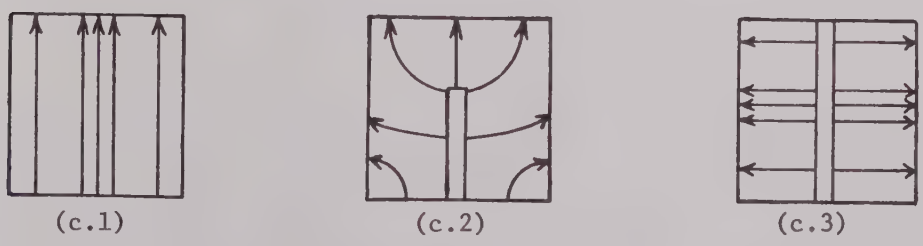
Viewed as a receiving device, the incident wave in the square guide section is circularly polarized. This wave can be considered as the combination of orthogonal TE_{10} components, one normal to the sloped septum and one parallel to the septum, with a relative phase between components of 90^{o}. As this wave propagates through the septum region the normal component divides



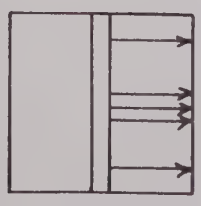
(a) Sloping Septum



(b) Normal Component



(c) Parallel Component



(d) Total Field at Rectangular Port

Figure 4-2. Feed Polarizer Section

equally between the rectangular ports while retaining instantaneous codirectional vector orientations, as indicated in Figure 4-2(b.1-b.3). The parallel component also divides equally between the rectangular ports, but produces diametrically opposed instantaneous vector orientations in the rectangular sections as indicated in Figure 4-2 (C.1-C.3). The continuous transition of guide cross-section and correspondingly of guide wavelength simultaneously produces a relative phase shift of 90° between components derived from the normal input component and the parallel input component. Thus, in one rectangular port the field components have 180° relative phase and cancel, while in the second rectangular port the components are in phase and add, as depicted in Figure 4-2(d).

This polarizer is a reciprocal device, so that a TE_{10} wave propagating from one rectangular guide section through the septum region into the square guide section will produce an RCP field comprised of orthogonal TE_{10} components in phase quadrature, while energy from the second rectangular guide would produce an LCP field in the square guide.

4.2.6 TRANSMIT/SUM-RECEIVE FEED HORN. The square-guide section of the feed polarizer interfaces with a pyramidal horn with small, equal flare angles in each plane. The square horn aperture is optimized for the desired primary pattern main lobe characteristic, to produce adequate amplitude taper over the main paraboloidal reflector.

4.2.7 14-FOOT PARABOLOIDAL REFLECTOR. The main reflector is a paraboloid of revolution. The spherical phasefront of the primary radiated wave the feed horn located at the paraboloid focal point is collimated into a planar phasefront at the aperture of the reflector. On reception, essentially planar phasefronts from distant sources are focused at the phase center of the feed horn aperture.

4.2.8 TRANSMITTER MONITOR DIPOLE. The vertex dipole utilizes the paraboloidal reflector surface as a ground plane. The dipole is made a half-wavelength at 2072.5 MHz, the mid frequency of the transmit band. A separation of less than 1/4 wavelength between the dipole and reflector at this frequency produces an essentially single-lobed directivity pattern whose axis lies along the main reflector axis. This dipole will thus extract a sample signal from the primary radiation of the transmit horn located at the focal point of the reflector.

4.3 DIFFERENCE-SIGNAL RECEPTION. A set of four dual-linear dipoles, located symmetrically about the flats of the square transmit/sum-receive feed horn, is used to form the squinted difference-channel lobes employed in forming azimuth and elevation boresight error signals. The eight resulting linear-component signals are transformed into sum and difference signals in menopulse comparator circuits. These sum signals are not used in this system and are terminated in matched loads. The linear-component difference signals are routed through quadrature 3-dB hybrids, producing a set of circularly polarized azimuth and elevation difference signals which are the connected to the difference-channel filters located in the preamp enclosures. The filtered signals pass through the through arms of test-injection couplers to the preamps.

The theory of operation for the major components of this portion of the Antenna Group is presented in the following subsections.

4.3.1 DIFERENCE-RECEIVE DIPOLE ARRAY. The four cavity-backed dual-linear dipoles, which are offset from the focal point of the main reflector in the azimuth and elevation planes, generate four squinted secondary RF beams. As shown in Figure 4-3, two of the beams are formed in the azimuth plane and two are formed in the elevation plane.

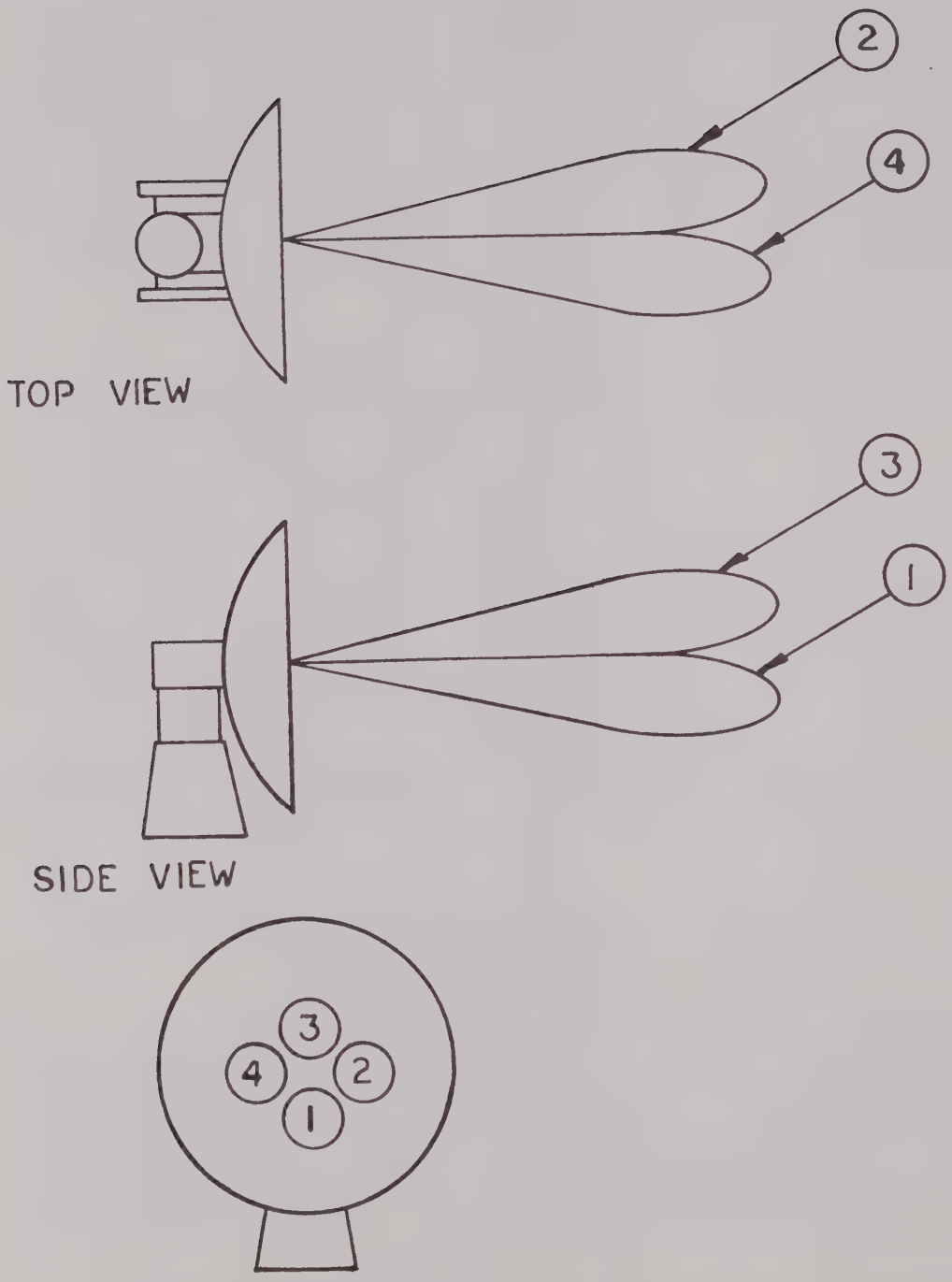


Figure 4-3. Tracking Beams Formed By Difference Dipole Array At Focal Plane Of Reflector

Each of the four individual difference-channel feed elements receives both vertically and horizontally polarized signals within the frequency band of 2200-2300 MHz. The total number of difference-array outputs is thus 8. The skewed beam associated with each element provides output signals when the direction of arrival of incident wavefronts is not directly on the boresight axis of the main reflector.

4.3.2 MONOPULSE COMPARATORS. The Model 80 Monopulse Comparators derive the copolarized linear differences between each of the skewed beams formed by the opposed difference feed elements. Figure 4-4 shows schematically the process of sum and difference signal formation via microstrip magic-tee junctions.

All connecting cables from the dipoles to the comparators are matched in length, thus have equal insertion phase. For example, assume an incident RCP wavefront. The horizontal elements of the elevation-plane dipole pairs extract signals which we shall name 1H and 3H; these signals arrive in phase at the sidearms of the first tee shown in Figure 4-4. Signal 1H is divided at half power between the sum arm and difference arm of the tee. Signal 3H similarly divides at half power between these arms, except that the difference arm signal undergoes a relative phase shift of 180^{o} compared to the 1H signal. The tee output electric field components are thus

$$\Sigma EL(H) = \frac{1}{\sqrt{2}} (1H+3H) \qquad (4.1)$$

and

$$\Delta EL(H) = \frac{1}{\sqrt{2}} (1H-3H). \qquad (4.2)$$

In the assumed incident RCP wavefront, the vertical field component logs the horizontal field component by 90 degrees in phase. Therefore, signals

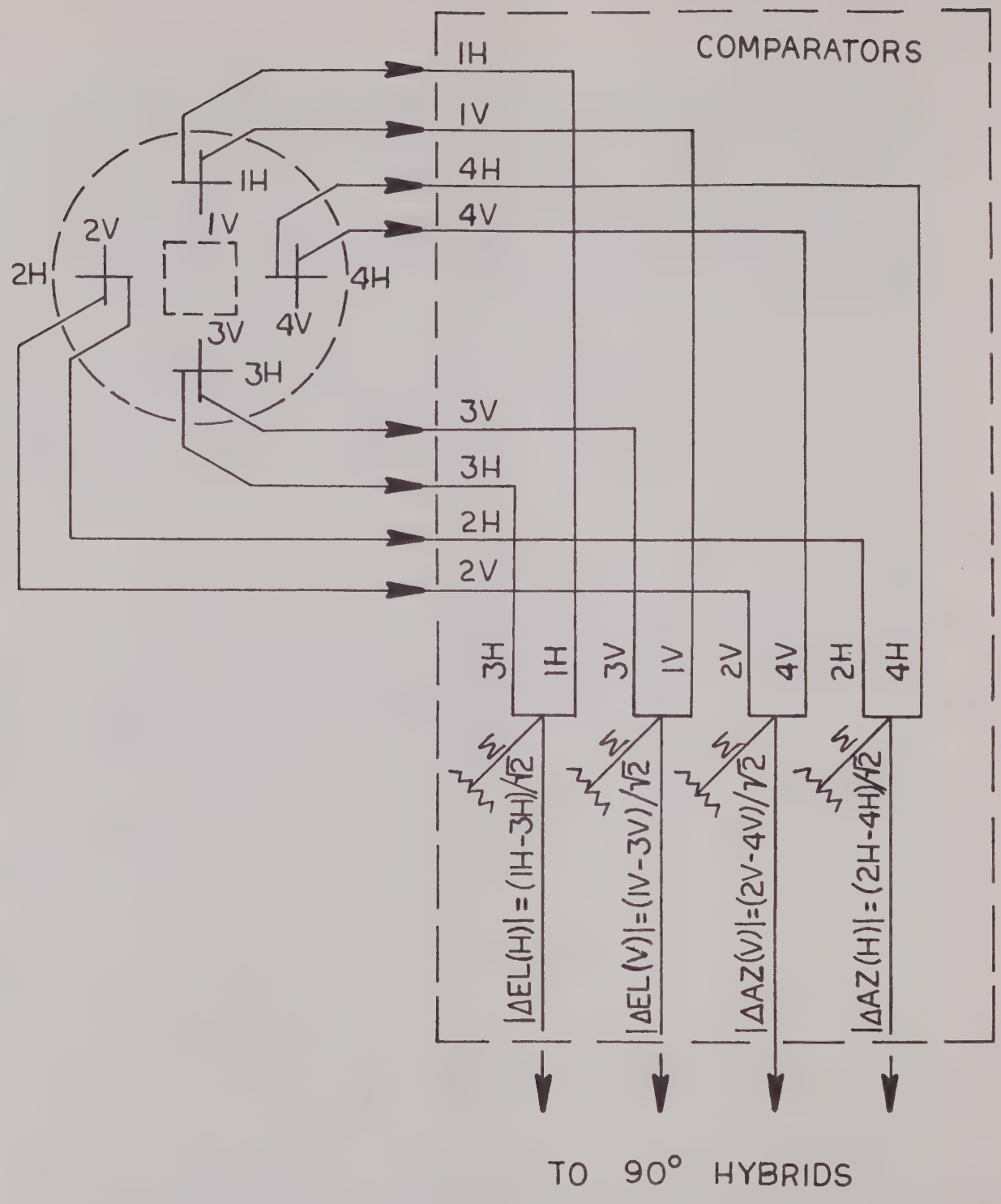


Figure 4-4. Schematic Diagram of Difference Signal Formation in Model 80 Comparators

1V and 3V from the vertical dipole elements of the elevation plane pair arrive at the second tee junction in phase with each other, but at a relative phase of -90^{o} with reference to the horizontal element signals. Thus the resulting sum and difference signals are given by

$$\Sigma \text{EL(V)} = \frac{1}{\sqrt{2}}(1V+3V) \exp(-j\pi/2) \tag{4.3}$$

and

$$\Delta \text{EL(V)} = \frac{1}{\sqrt{2}}(1V-3V) \exp(-j\pi/2). \tag{4.4}$$

Retaining the same horizontal component phase reference, it is seen that the azimuth plane signal pairs extracted from an incident RCP wavefront pass through their associated tee junctions to yield

$$\Sigma \text{AZ(H)} = \frac{1}{\sqrt{2}}(2H+4H), \tag{4.5}$$

$$\Delta \text{AZ(H)} = \frac{1}{\sqrt{2}}(2H-4H), \tag{4.6}$$

$$\Sigma \text{AZ(V)} = \frac{1}{\sqrt{2}}(2V+4V) \exp(-j\pi/2), \tag{4.7}$$

and

$$\Delta \text{AZ(V)} = \frac{1}{\sqrt{2}}(2V-4V) \exp(-j\pi/2) \tag{4.8}$$

For an LCP incident wavefront, the vertical field component leads the horizontal field component by 90^{o} degrees in phase. Again adopting the horizontal field components as arbitrary phase reference, the sum and difference signals formed in the comparators would be expressed as in (4.1)-(4.8) except that the exponentials in (4.3), (4.4), (4.7) and (4.8) would be replaced with $\exp(+j\pi/2)$.

All sum signals formed in the comparator circuits are dissipated in matched coaxial terminations. The difference signals are routed to the hybrid combiners discussed below in a set of matched-phase-length cables.

4.3.3 DIFFERENCE CHANNEL HYBRIDS. The four linear-component difference signals are combined in pairs via 90^{o} 3dB hybrids as indicated schematically in Figure 4-5. Each input signal to the hybrid is divided at half power between its in line and off set output ports, while the offset path signal obtains a relative phase advance of 90 degrees with reference to the inline path signal. This combination results in the output conditions shown in Figure 4-5(a), for an incident RCP wavefront at the dipole array. For an LCP incident wavefront, the phase-additive condition results at the second hybrid output port as indicated in Figure 4-5(b).

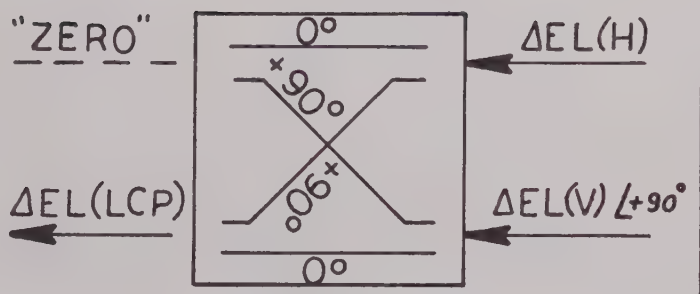
For either ideally polarized CP condition of the incident wavefront, the resulting difference signal electric field components can be expressed as follows:

$$\Delta EL(CP) = \frac{1}{\sqrt{2}}\Delta EL(H)+\Delta EL(V) = \frac{1}{2}(1H-3H)+(1V-3V) \qquad (4.9)$$

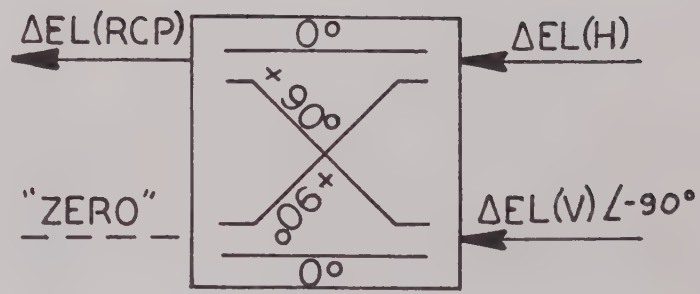
$$\Delta AZ(CP) = \frac{1}{\sqrt{2}}\Delta AZ(H)+\Delta AZ(V) = \frac{1}{2}(2H-4H)+(2V-4V) \qquad (4.10)$$

In the operational situation, all incident wavefronts will be somewhat elliptically polarized, so that the difference output lines will have corresponding RCP and LCP components whose relative amplitudes depend on the ellipticity of the incident field polarization. Each difference signal output is routed from the hybrids to the coaxial bandpass filters located in the preamp enclosures at the rear of the reflector.

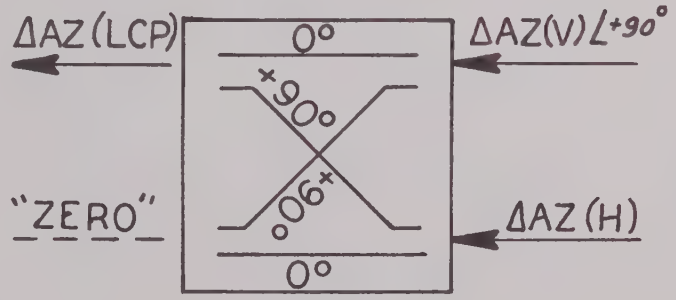
4.3.4 DIFFERENCE CHANNEL FILTERS. The four difference channel filters are passive bandpass comb line units. A 0.01dB Chebyshev design with thirteen



(a) Hybrid Outputs for RCP Incident Wave



(b) Hybrid Outputs for LCP Incident Wave



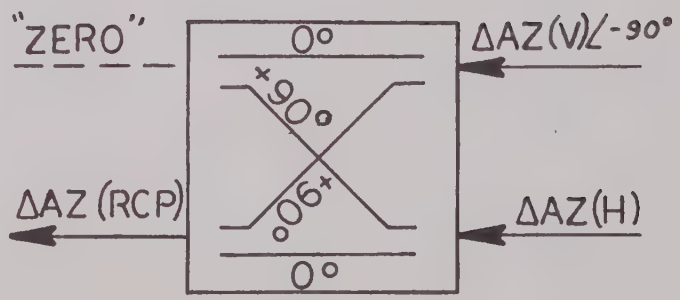


Figure 4-5. Schematic Diagram of Difference Signal Combination in 90° Hybrids

Y388

folded-construction comb resonators is employed.

4.4 PREAMPLIFIERS. The six identical preamps for the CP difference and sum receive signal lines are microwave bipolar silicon transistor amplifiers. The design affords protection against zero level inputs or shorted inputs. Adjustable gain over a 15dB range is voltage controlled, altering the bias voltage for PIN diode attenuators integrated in the chips.

Each set of three preamps is provided prime power via a 115v ac/28v dc power supply, with the +28v dc potential supplied to both bias terminals of each amplifier via a bus. Ground is common to each set of amplifiers, the dc supply and the input ac power line.

4.5 TEST INJECTION CIRCUITS. The test injection circuit includes three basic types of stripline power combiners. The test input from a CFE unit is divided at half-power in the 2-way divider located in the base extension of the pedestal. This divider is a four-port hybrid magic tee, where the odd-mode excitation is internally terminated,yielding two in-phase outputs at -3dB levels with reference to the input.

Each output is routed to a 4-way divider located in the associated RCP or LCP preamp enclosure at the rear of the reflector. These dividers are comprised of a set of three 2-way dividers in an integrated package, where each 2-way divider is as described above. Of the resulting four in-phase outputs, each at -6dB with reference to the signal input from the initial 2-way divider (-9dB nominal with respect to the CFE input, one output is terminated in an external coaxial load and the remaining three outputs are connected to the coupled arms of the test couplers.

The through arm of each coupler is in the main receive path for the difference and sum receive signals previously discussed. Coupling factors of -20dB with reference to the through arm are established by the relative

line width and spacing of the stripline circuits of the paths. The fourth isolated port of each coupler's stripline circuit is internally terminated in a resistive load.

SECTION 5. MAINTENANCE

5.1 GENERAL

All enclosures and RF paths of the Antenna Group are sealed, and should require no corrective maintenance for the life of the equipment. The only preventive maintenance routine unique to the Antenna Group is that of inspection and cleaning of the feed enclosure and vertex dipole radome at intervals dependent upon the operational environment.

(1) Inspect the feed and vertex dipole radomes for moisture, dirt and other foreign materials. Use a clean lint-free cloth lightly moistened with a dilute solution of mild soap and water ro remove any foreign materials from all accessible surfaces. Wipe dry using a clean, dry, lint-free cloth.

(2) Inspect feed and waveguides for dents, distortions and bends.

Note

To assure ejection of any foreign materials in the RF paths in the event that feed radom removal is required, purge the system with dry air at a maximum pressure of 2 psig subsequent to radome replacement.

WARNING

Feed inspection or operation of associated pressurization valves can expose personnel to focused electromagnetic energy. Do not attempt to inspect or clean feed or to operate associated purge valves while the system transmit power is energized, or when the system is pointed toward nearby high-power radiators of any frequency.

The alignment and focusing of the feed/reflector assembly has been established in antenna range measurements, and the feed fixed in place at installation.

Note

To assure proper system RF alignment, do not attempt to refocus or realign the feed system to correct for boresight errors which may be due to multipath or malfunctioning components.

Active or electromechnical devices in the Antenna Group include the waveguide switch and associated control unit, the preamplifiers and associated dc power supplies, the the coaxial rotary joints. With the exception of the control unit for the switch (not a part of this manual), all these items are either factory repairable or expendable, and corrective maintenance consists of replacement of the items from system spares or subsequent to factory repair.

WARNING

Removal of any RF component within the pressurized coaxial or waveguide runs, or opening of the preamp enclosures or feed enclosure, while pressurized, could result in personnel injury. Insure that all purge valves are open and the system pressurization is disabled prior to removal of components or opening of enclosures.

SECTION 6. PARTS LIST

6.1 GENERAL

All parts lists associated with the Antenna Group are included on the various assembly drawings; see Section 7 of this manual. It is noted that the active RF devices, one waveguide switch and six transistor amplifiers, are factory repairable items. The electrical subsystems include two 28 vdc power supplies which are replaceable at the unit level from spares, and the control unit for the waveguide switch, which is covered in the system manual. The two coaxial rotary joints are factory repairable electromechanical devices. All remaining components of the Antenna Group are passive RF devices or standard items of mechanical or electrical hardware.

SECTION 7. DRAWINGS

7.1 GENERAL

This section lists and presents all pertinent drawings for the Antenna Group which have not been included in previous sections of this manual or in separate manuals. A separate listing is provided for those drawings included in separate manuals, which encompass components of the Antenna Group.

7.2 DRAWINGS INCLUDED IN SEPARATE MANUALS

Table 7-1. Antenna Group Associated Drawings of Separate Manuals

Antenna Group Component	Dwg. Title	S-A Dwg. #	Manual
Polarization Control Unit	Polarization Control Unit Panel	163876	System
Polarization Control Unit	Polarization Control Panel Assy.	163877	System
Polarization Control Unit	Polarization Control Panel Schem.	163744	System
Az. Rotary Joint	Component Location Az. 3204 Series	161938	System
El. Rotary Joint	Component Location El. 3204 Series	161939	System
2-Way Power Divider	Base Extension	159242	System
2-Way Power Divider	Base Extension Schem. Diag.	159992	System
Waveguide	System Assembly	161918	System
Coaxial Units	System Assembly	161918	System
Cable Drawings	(Various)	(Various)	System

7.3 DRAWINGS INCLUDED IN THIS MANUAL

Table 7-2 Antenna Group Drawings of This Manual

Figure No.	Drawing Title	S-A Dwg. No.
7-1	System Assembly	161918
7-2	Reflector Assembly	161917
7-3	Spar Mounting Assembly	161916
7-4	Feed Assembly	161900
7-5	Vertex Dipole Assembly	161981
7-6	RF Box Assembly	164415
7-7	Schematic Diagram V213 RF Subsystem	159971
7-8	Waveguide Switch Schematic Diagram	163879

64	2	161954	WAVEGUIDE			
63	6		WASHER FLAT	1" SCDP		
62	6		WASHER, FLAT	3/4 SCDP		
61						
60	6		NUT, HEX	3/8-10UNC SCDP		
59						
58	6		SCREW, HEX HD	3/8-10 UNC × 6LG SCDP		
57	6		SCREW, HEX HD	1-8 UNC × 8LG SCDP		
56						
55	2	161948	BAR, SW SPACER			
54	1	161900	FEED ASSY			
53	1	161981	VERTEX DIPOLE ASSY			
52	2	86470	SOCKET, RELAY	8 PIN	27E122	PB
51	1	86781	JACK, PHONE	3 COND 3 WIRE	N-1178	SC
50	2		LATCH		07-10-101-12	9822E
49	1	72900	EM DISABLE SW	250VAC, 10A, DPST	7561K4	CH
48	1	157595	COAX/WG ADP		DIC-351	01882
47	1		BASE, SCOPE		#85-1	⚠2
46	1		SCOPE	30× MAGNIF	#83	⚠2
45	1		TERMINATION		T350N	18203
44	2	71799	RELAY	115VAC DPDT OCTAL	KRP11AG	PB
43	2		H PLANE ELBOW	45°	12258	00443
42	1		AIR DRYER		MODEL 550	⚠1
41	2	140495	DIPLEXER		430DEP199	01456
40	1	157588	SWITCH		4377 E	00443
39	4		E PLANE ELBOW	90°	430BE14	01456
38	2		WAVEGUIDE TWIST	15 IN. LG	4390-2	00443
37	4		H PLANE ELBOW	90°	430BH14A	01456
36	2		E PLANE ELBOW	45°	12250	00443

35	A/R	80272	GASKET			
34	1	161960	MOUNT, SCOPE			
33	2	161961	HINGE, SCOPE COVER			
32	1	161959	COVER, SCOPE			
31	1	161962	MOUNT, SCOPE			
30	2	161963	MTG BAR, DRYER			
29	1	19673	COVER, ACCESS			
28	1	161958	COVER, ELECT			
27	1	161919	PRESSURE SYSTEM			
26	2	126497	COVER, CNT GRM			
25	1	106884	POWER CONTROL			
24	1	162782	CONNECTOR PANEL			
23	2	140180	POWER AMP			
22	CIE		DOWNCONVERTER			M-2750
21	1	84836	POWER DIVIDER	1GHz TO 2GHz	40756	ANE
20	3		COAX/WG ADAPTOR	SEALED	LA-90-UGM	⚠3
19	2	164415	ENCLOSURE			
18	2	161946	MTG PLATE			
17	4	161945	MTG BRACKET			
16	4	161944	MOUNT, DIPLEXER			
15	1	161947	MTG BRACKET			
14	2	163874	WAVEGUIDE FLEXIBLE	12.92 LG		
13	2	161952	CLAMP			
12	2	161957	WAVEGUIDE			
11	2	161950	CLAMP			
10	2	161951	CLAMP			
9	2	161956	WAVEGUIDE			
8	2	161955	WAVEGUIDE			
7	2	124507	SIDE ARM			
6	6	64845	LEVELING FOOT			
5	1	161937	PEDESTAL ASSY			
4	26	126495	COUNTERWEIGHTS			
3	1	161916	SPARE MTG ASSY			
2	1	161917	REFLECTOR ASSY			
1	1	159242	BASE EXTENSION			

ITEM OR FIND NO.	QTY REQD	S-A STOCK NO.	NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT

PARTS LIST

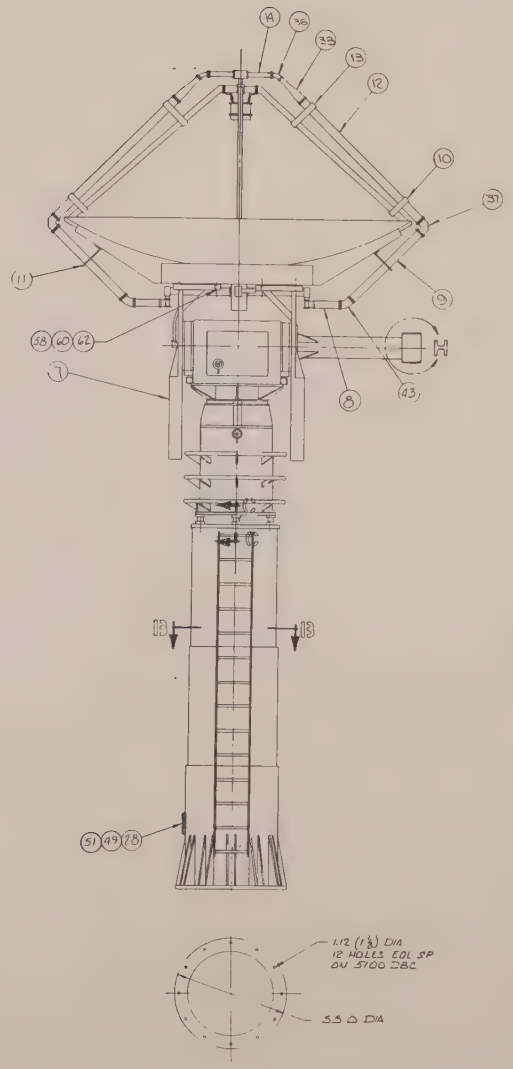
NOTE:

⚠1 GENERAL CABLE
5400 N. 88TH AVE.
WESTMINSTER, COLORADO 80030

⚠2 BRUNSON INSTRUMENT CO.
3000 E. 23RD ST.
KANSAS CITY, MISSOURI 64127

⚠3 MICROWAVE RESEARCH CORP
1429 OREGOD ST.
N. ANDOVER, MASS. 01845

Figure 7-1. System Assembly
(sheet 1 of 4)



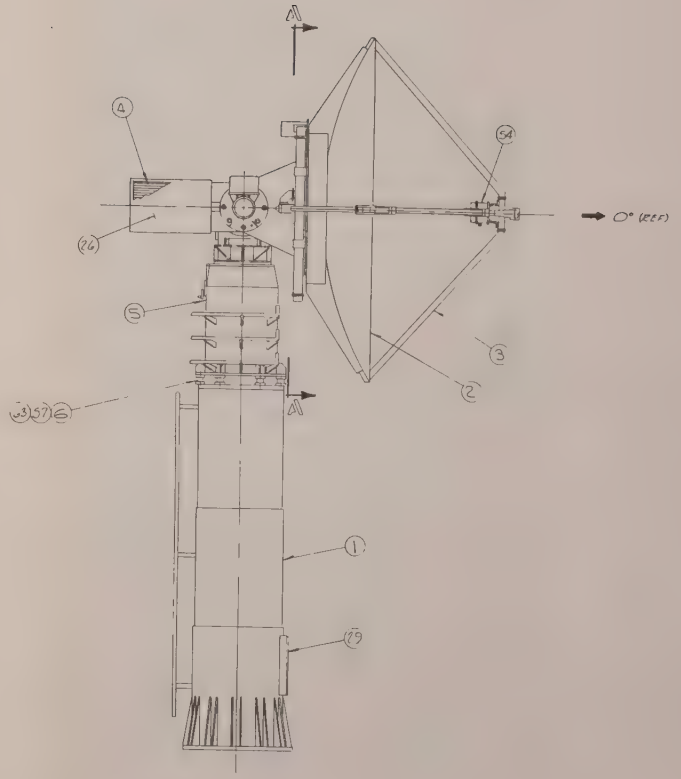
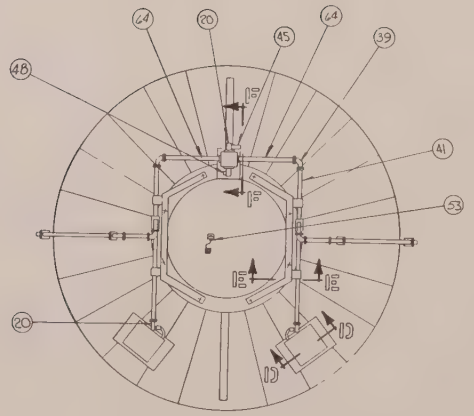
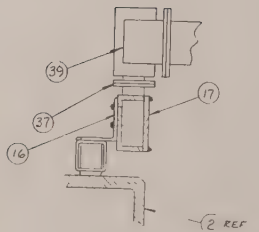
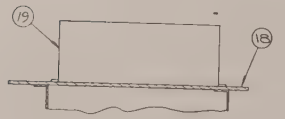


Figure 7-1. System Assembly
(sheet 2 of 4)







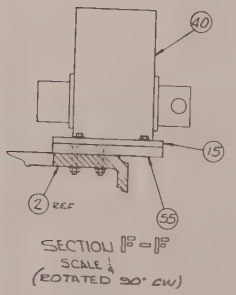
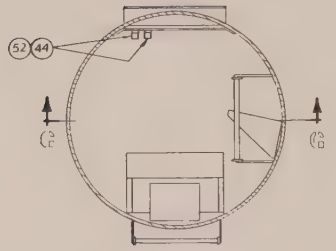
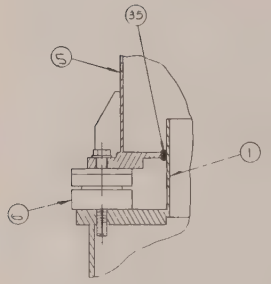
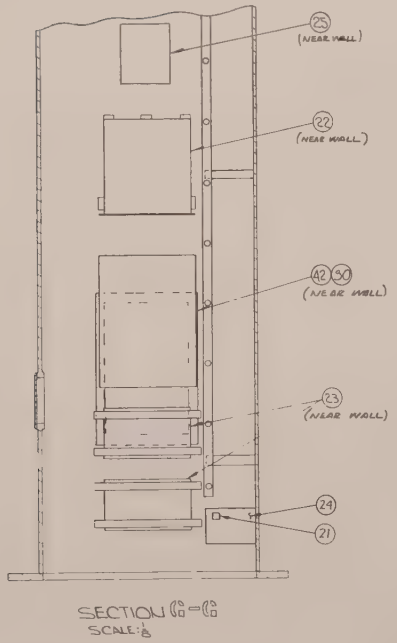
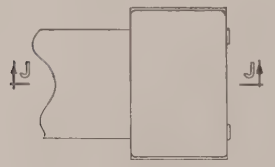


Figure 7-1. System Assembly
(sheet 3 of 4)









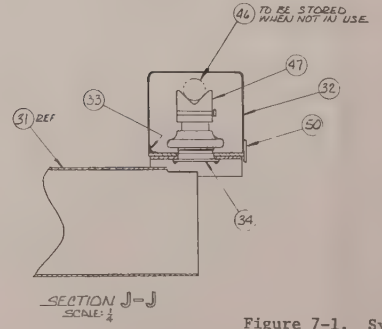
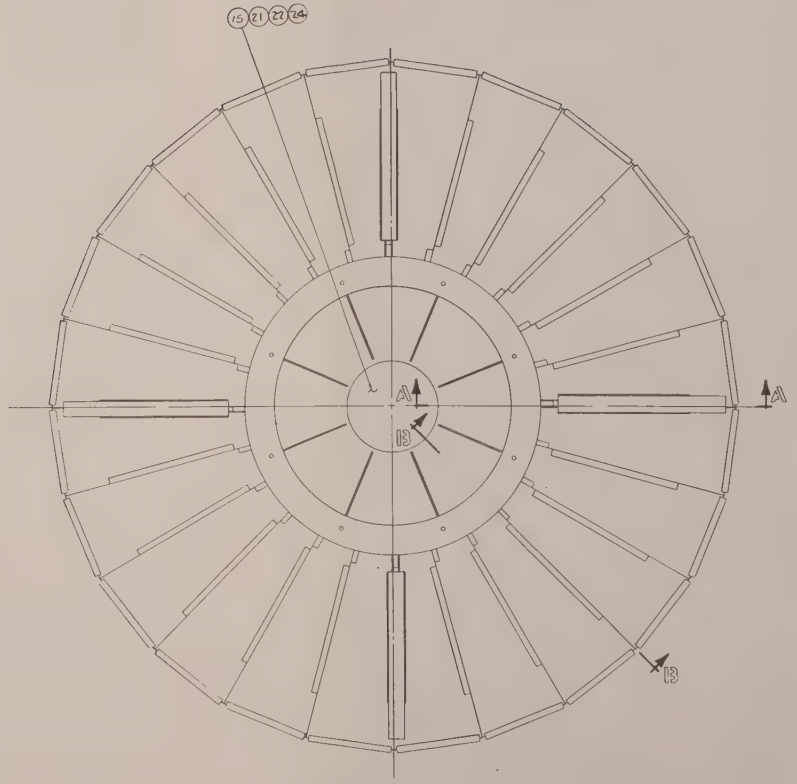


Figure 7-1. System Assembly
(sheet 4 of 4)



NOTE
1. REFER TO DRAWING 161983 WHEN DISASSEMBLING REFLECTOR.

Figure 7-2. Reflector Assembly
(sheet 1 of 3)

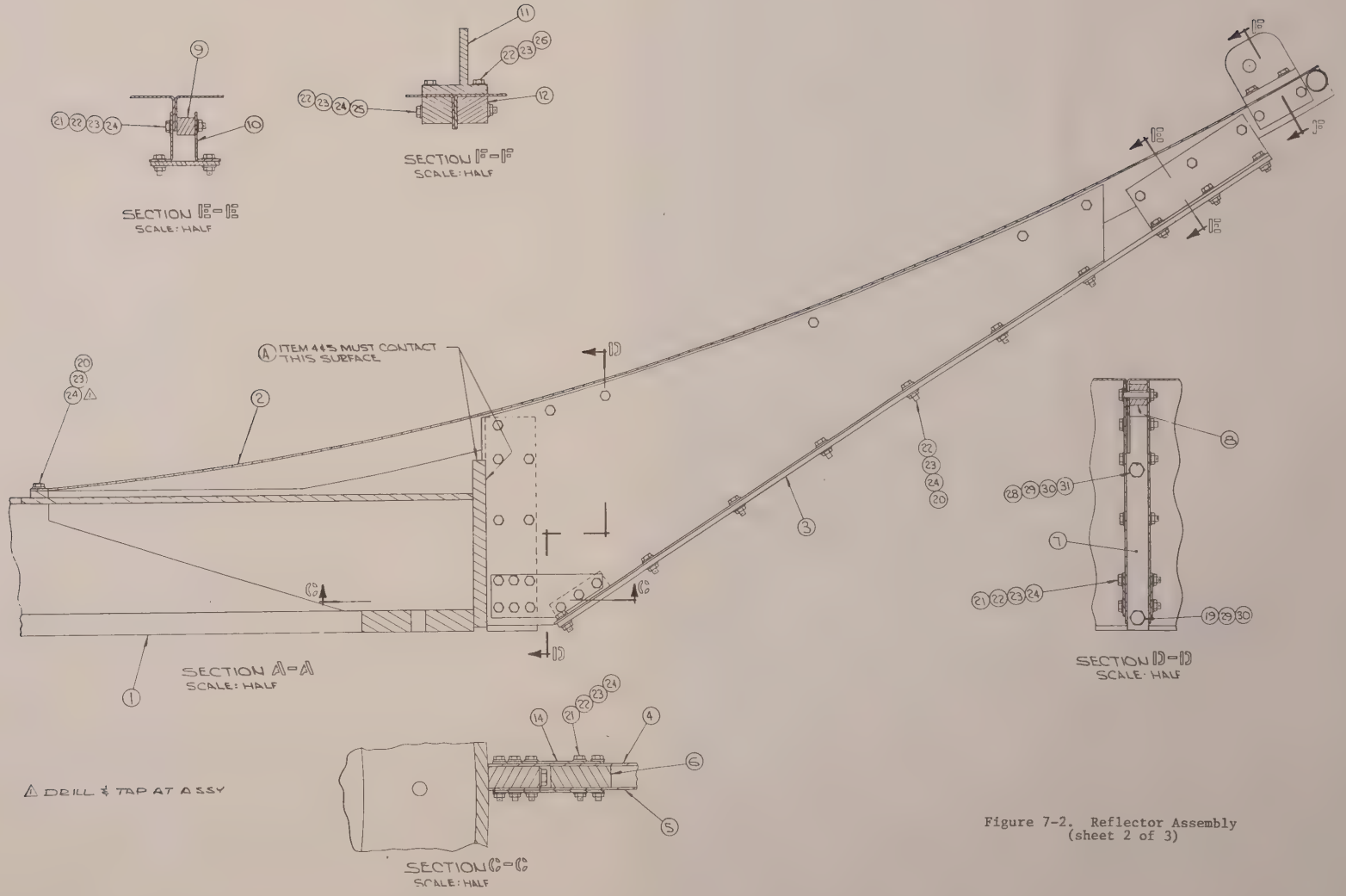


Figure 7-2. Reflector Assembly
(sheet 2 of 3)

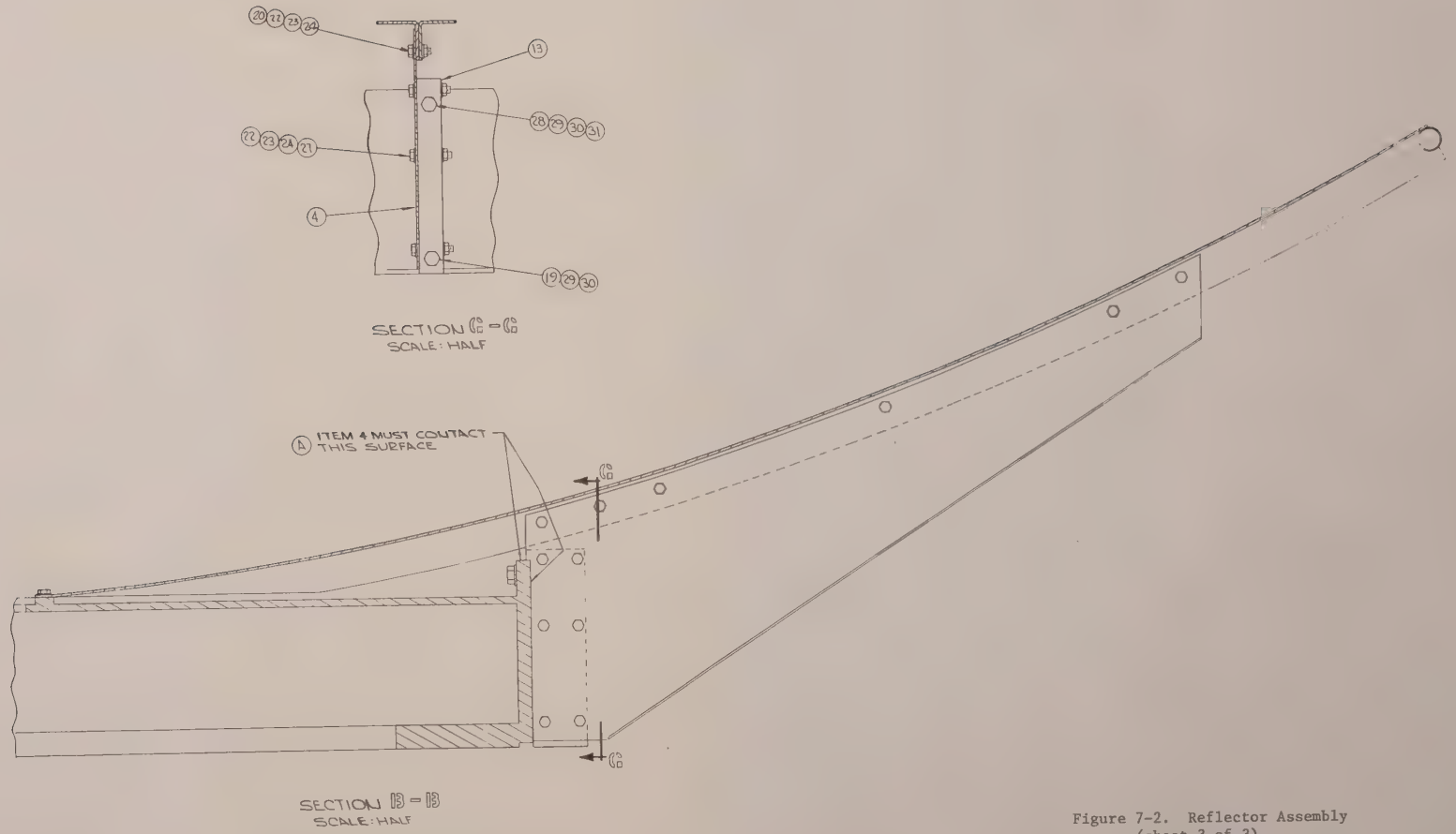


Figure 7-2. Reflector Assembly
(sheet 3 of 3)

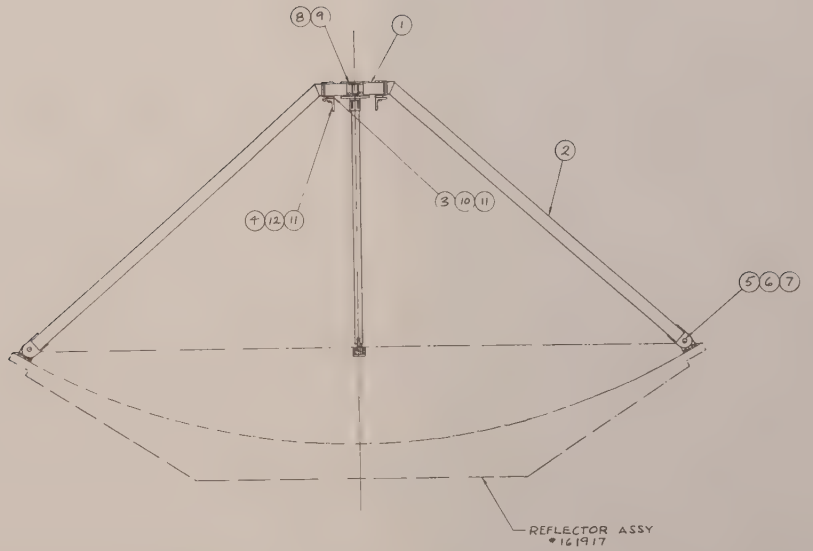


Figure 7-3. Spar Mounting Assembly

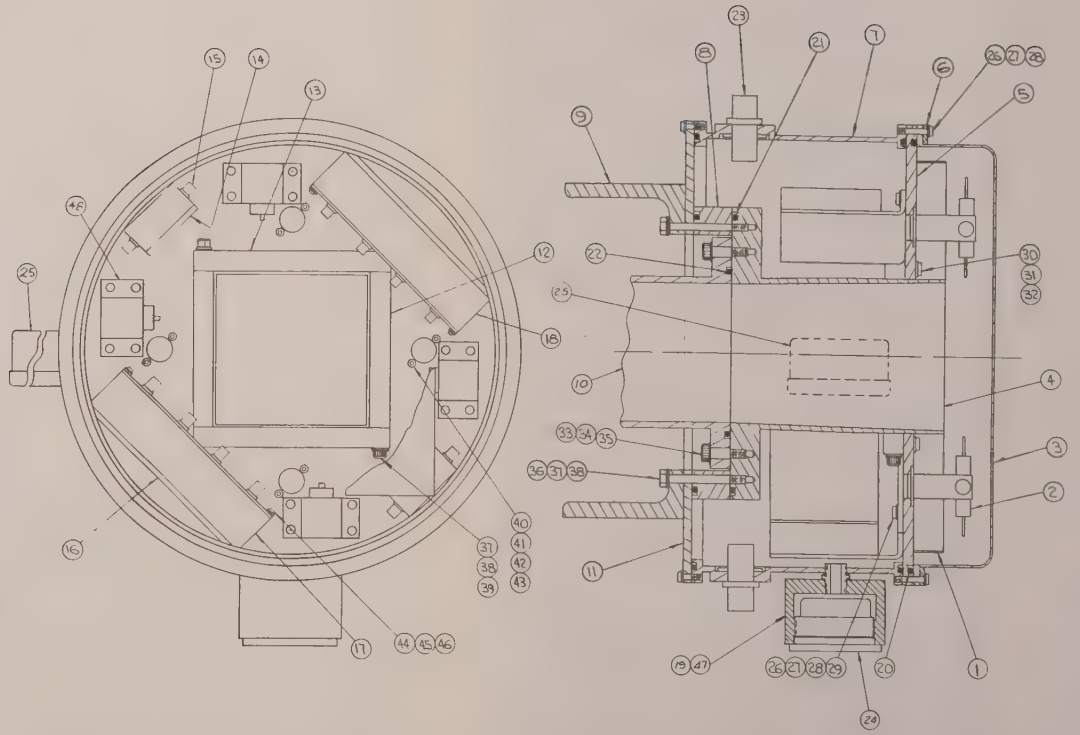


Figure 7-4. Feed Assembly

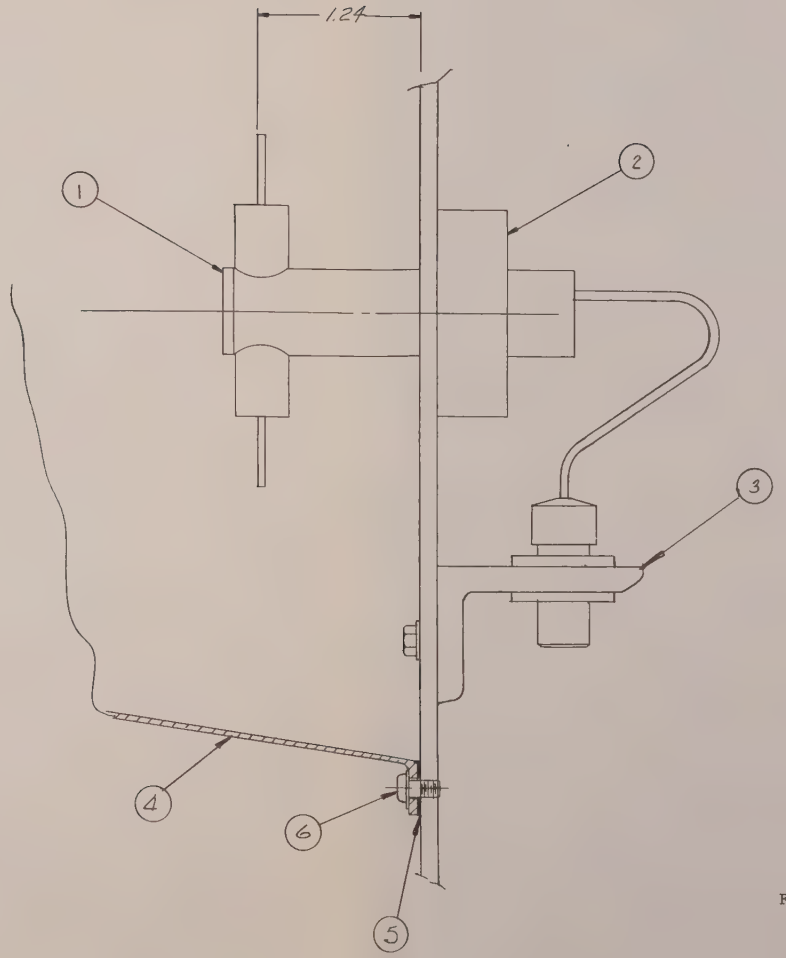
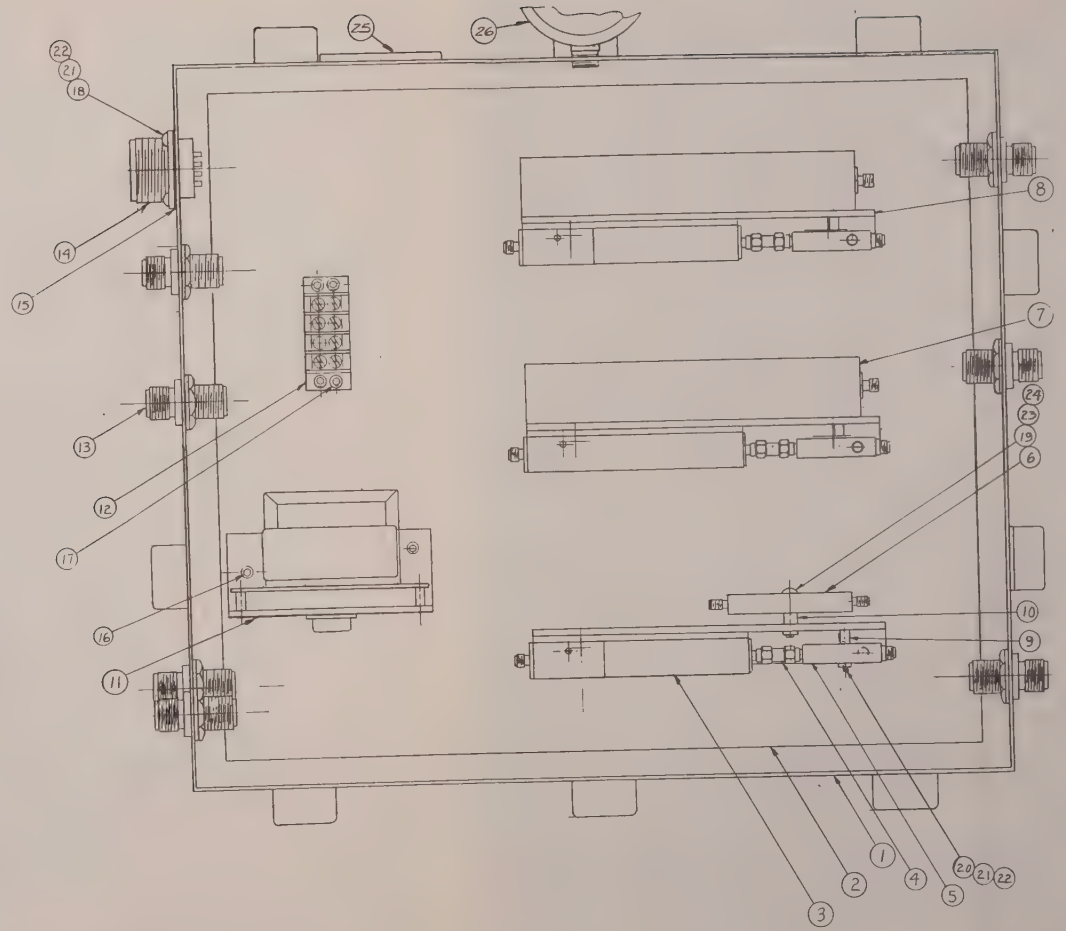
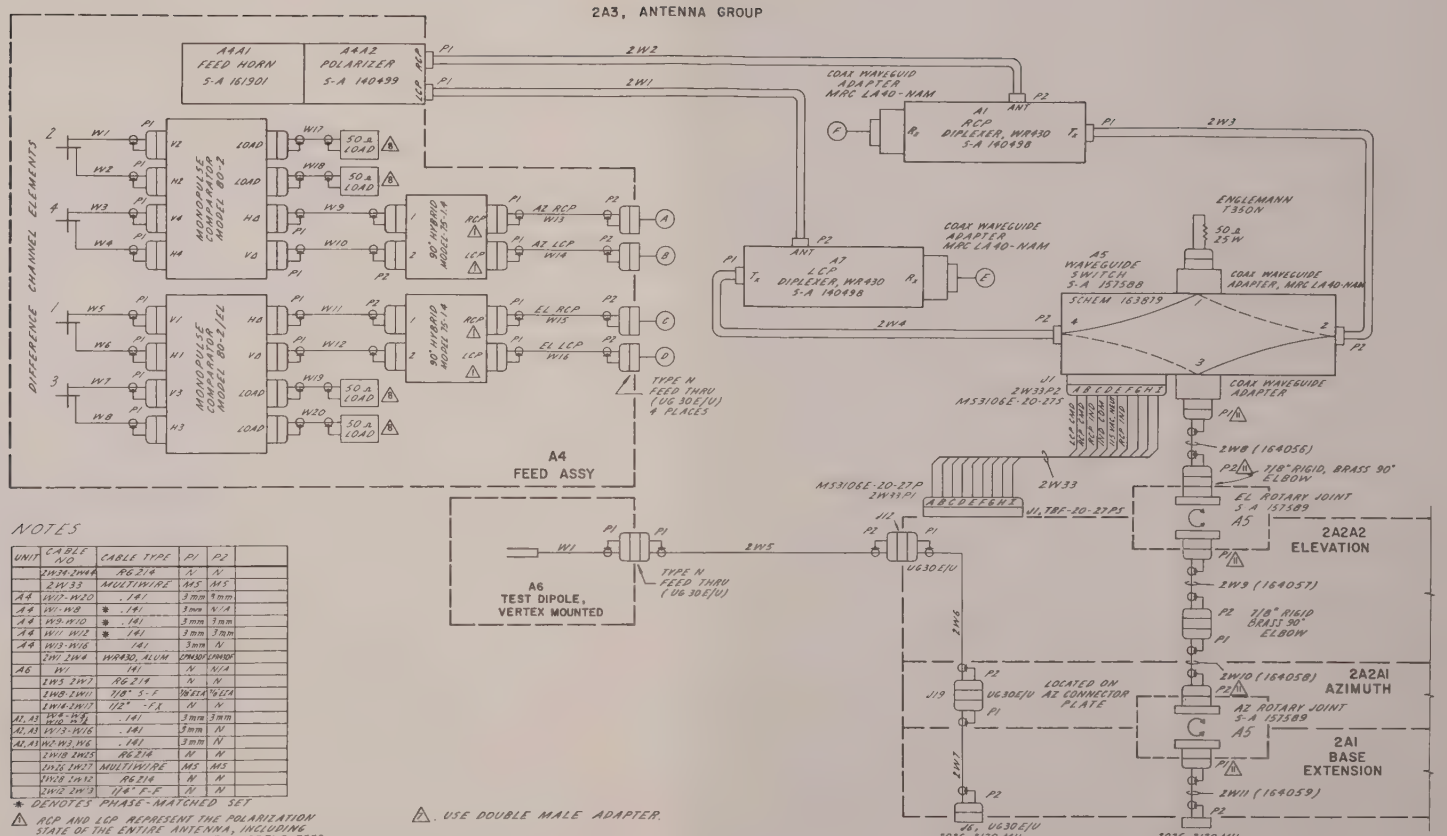


Figure 7-5. Vertex Dipole Assembly



1. OMNI-SPECTRA/AMERICAN 140 4TH AVE. W., WALTHAM, MA.
2. ELECTRO STATICS 7718 CLAIRMONT MESA BLVD, SAN DIEGO, CALIF
3. AGM CARGO TIES, INC. P.O. BOX 6089 TUCSON, ARIZONA 85716
4. MARSH INSTRUMENT CO. SKOKIE, ILL

Figure 7-6. RF Box Assembly



NOTES

UNIT	CABLE NO	CABLE TYPE	P1	P2	
	2W34-2W44	RG 214	N	N	
	2W33	MULTIWIRE	MS	MS	
A4	W17-W20	.141	3mm	9mm	
A4	W1-W8	* .141	3mm	4/4	
A4	W9-W10	* .141	3mm	3mm	
A4	W11-W12	* .141	3mm	3mm	
A4	W13-W16	.141	3mm	N	
	2W1 2W4	WR430, ALUM	UM430F	UM430F	
A6	W1	.141	N	N/A	
	2W5 2W7	RG 214	N	N	
	2W8-2W11	7/8" S-F	7/8 EIA	4½ LA	
	2W14-2W17	1/2" F-F	N	N	
A1, A3	W1-W4	.141	3mm	3mm	
A1, A3	W5-W8	.141	3mm	N	
A1, A3	W9-W12	.141	3mm	N	
A1, A3	W1, W3, W6	.141	3mm	N	
	2W18 2W25	RG 214	N	N	
	2W26 2W27	MULTIWIRE	MS	MS	
	2W28 2W32	RG 214	N	N	
	2W42 2W43	1/4" F-F	1/4	N	

* DENOTES PHASE-MATCHED SET

⚠ RCP AND LCP REPRESENT THE POLARIZATION STATE OF THE ENTIRE ANTENNA, INCLUDING THE REFLECTOR. POLARIZATION OF THE FEED ITSELF IS OPPOSITE THAT INDICATED.

2. DIFFERENCE CHANNEL DIPOLE LOCATIONS AS VIEWED FROM THE REFLECTION VERTEX.

3. .141 CABLE IS SEMI-RIGID, S-A 76987, TIMES WIRE CL-50141T. N-CONNECTORS ARE MALE, S-A 78168; 3mm CONNECTORS ARE MALE, S-A 76916.
4. 7/8" S-F CABLE IS HELIAX, ANDREWS AWS-50. 7/8" EIA CONNECTORS ARE BRASS ANDREWS 75 A/A.
5. 1/2" F-F CABLE IS FOAMFIL, CABLEWAVE FXA-12-50U N-CONNECTORS ARE MALE, CABLEWAVE 734509
6. RG214 CABLE IS S-A 70818; N CONNECTORS ARE MALE UG1185A/U - AMPHENOL 82-3312

⚠ USE DOUBLE MALE ADAPTER.

⚠ ENGLEMANN MICROWAVE T 451 M, 25 WATTS.

9. 1/4" F-F CABLE IS FOAMLEX, CABLEWAVE FXA-14-50U. N CONNECTORS ARE MALE CABLEWAVE 735 300.

10 90° ELBOWS ARE ANDREWS TYPE 1060 METER ELBOW

⚠ SEE S-A PROCEDURE 164047 FOR TINPLATING BRASS CONNECTORS AT THESE JOINTS.

Figure 7-7. Schematic Diagram RF Subsystem (sheet 1 of 2)

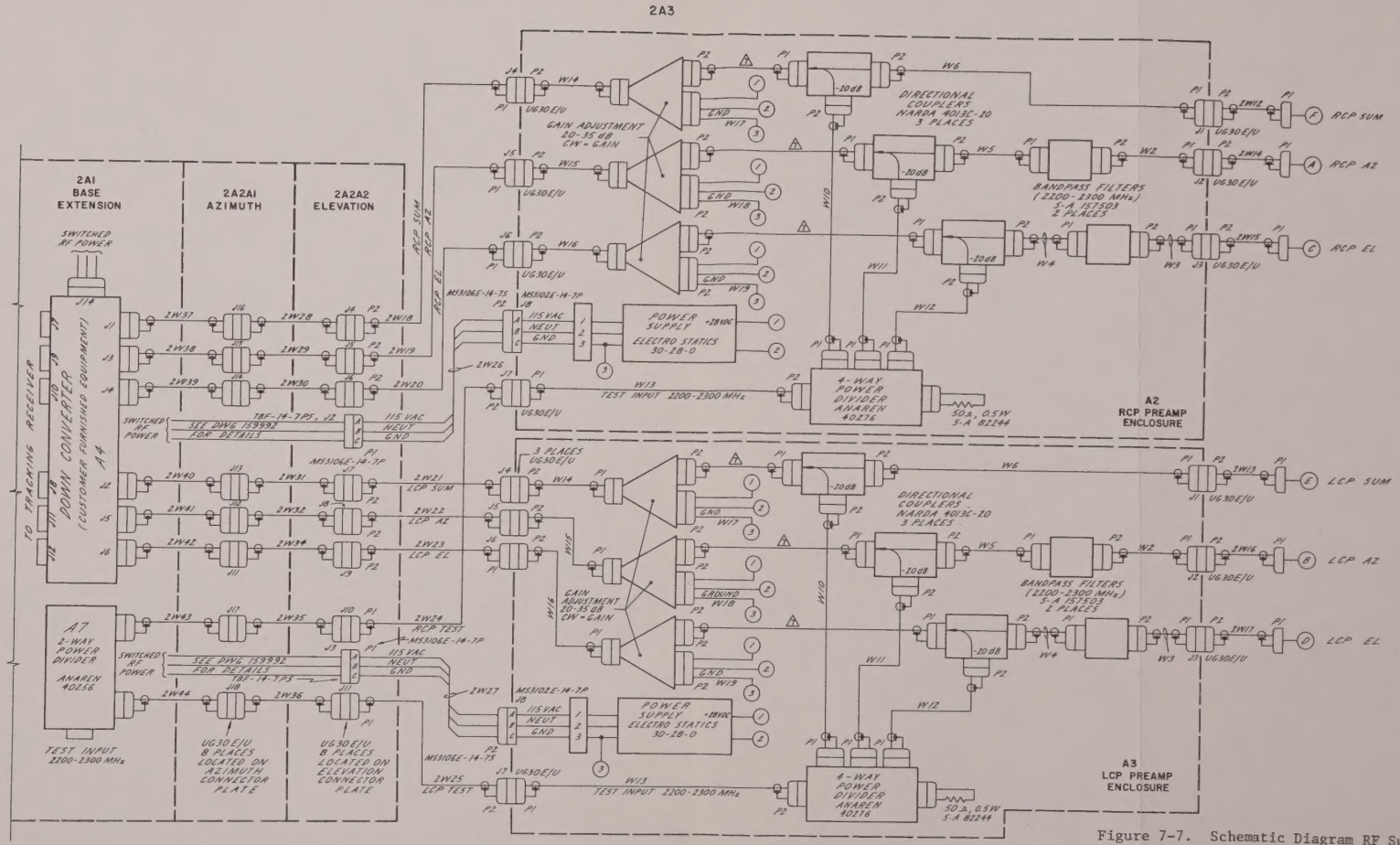


Figure 7-7. Schematic Diagram RF Subsystem (sheet 2 of 2)

MP MASTER
MA29895